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PAPER AND PAPER STANDARDS.[1]

THE editor of this periodical has requisitioned a contribution on the subject of "Paper". The author of "these presents" is perhaps directly responsible for a slight disturbance of official serenity in this matter. We all commit ourselves *to* paper, and for better for worse the *litera scripta manet*, or should do. The suggestion that this dictum may be falsified by the unexpected dissolution of the paper which carries our precious cargo of records on the ocean of time is sufficient ground for at least momentary pause to our official publishing bodies.

The suggestion is, we admit, a little *ad captandum*. But it is pardonable as an opening to the consideration of the much broader subject of Paper Standards.

Paper, or rather papers, are products of industrial evolution. The selection has been the "natural" one, and the result is a compromise; in every direction compromise. If the average Englishman (himself also a compromise) were asked to name his ideal in paper, he would, of course, for mixed but none the less obvious reasons, name the Bank of England Note. It will be considered an impertinence on our part to express a doubt as to whether this prototype of conventional excellence in paper is not capable of important improvements; from our point of view, however, there

[1] An informal discussion of matters dealt with in Report of Soc. of Arts Committee on "Deterioration of Paper". *Journ. Soc. Arts*, 1898, 46, 597. See also *ibid.*, 1897, 45, 690-696.

is not even a doubt. Of course it is improvable, and for reasons which will presently appear.

Our Art papers—what of them? All of course excellent, for are they not the product of half-unconscious selections accumulated through generations? Tested, however, by the standards of science, they are found wanting.

But—we are still following the *ad captandum* method and perhaps gratuitously—we do not know that it is necessary to base an appeal for the extension of scientific method to a hitherto unappropriated field by a demonstration of defects in that field, and corresponding remedies resulting from their more exact scientific study. To the popular judgment it is a very concrete proof of potential progress, and may be interjected as the necessary stimulant to positive thinking. Readers of SCIENCE PROGRESS are accustomed to another discipline. Whether as actual investigators or as appreciative critics they recognise an element of passion or sentiment in the mere extension of the intellectual horizon, in penetrating into the inner workings of things, which justifies effort and makes work self-sufficient and independent of outside stimulus. So let it be with them in all that appertains to paper, regarded as an aggregate of well-defined chemical individuals and structural units—in other words, as an eminently fit subject for scientific treatment.

Of course a great many of us have taken the commodity into use without inquiring as to what it is. Life in fact is not long enough for more than superficial general knowledge. Outside that small field in which we may enjoy the specialist's privilege of feeling "at home," we must accept the services of the guide-book or the "personal conductor" and be content with knowledge more or less second-hand. Our justification is in the well-worn truism: *Ars longa vita brevis;* but always qualified by the schoolboy's translation "Life is short but the ears of the ass are long," providing a salutary reminder that a "little knowledge," of the second-hand order, may be a "dangerous thing". An apt illustration comes to hand from actual and not very remote experience. The author was approached by an enthusias-

tical empiric, supported by an amiable, *i.e.*, long-suffering, capitalist, who had undertaken a scheme of making paper from "spent" hops. Of course it is known to the enlightened that paper can be made from anything from thistledown to deal boards, or should the vegetable world fail us, from asbestos to china clay. The initial advantage of a raw material costing nothing had appealed to the capitalist, and his empiric "will-o'-the-wisp" was justified by the above luminous generalisation rising from the morass of technical stagnation. But the point of our story is in a later episode. Our pioneer friend had been advised to boil his spent hops with *milk of lime.* An order had been sent to one of our wholesale druggists (sometimes mis-named "chemists") for a supply of the material, and when we came on the scene we found that to this order *Calcium lactate* had been supplied and was being freely used in the boiling of the spent hops.

For the pathos and comedy of spent hopes we doubt whether the chemist's experience can be equalled!

We have not forgotten that we are writing about a specific subject, neither have we forgotten that readers of SCIENCE PROGRESS are not of the order to be impressed by text-book disquisitions on scientific matters. The technical history of paper and the chemistry of the raw materials of which it is composed are ofttold stories. What we may point out without risking an accusation of tedious iteration, is that the writing and printing papers of our date are extremely "select" as regards raw materials. Of the hundred and forty and four thousand possible sources of supply, we have narrowed down to some half-dozen of the vegetable fibrous substances. Thus of the dicotyledons, one seed hair (cotton) and two bast fibres (flax and hemp); of the sub-class gymnosperms the wood-cells (fibres) of the stems of conifers; of the monocotyledons the stem tissues of the cereal straws and of esparto.

These materials are employed not in their raw condition. They are chemically treated for the isolation of cellulose. The treatments are designed to remove their more reactive or non-cellulose groups and to leave a chemically inert or non-reactive residue. Such is the com-

plex which we designate cellulose. Judged by the chemical criterion the paper-maker's celluloses divide themselves into three well marked groups which we may designate by their typical representatives as the Cotton, Wood and Esparto groups; and these groups correspond with the classification of the botanist.

This has only to be pointed out in specific terms to those accustomed to the positive discipline of natural science and they will start at once to inquire whether the sheet they are now handling is of the rag, wood or esparto class, knowing perfectly well that important consequences must follow from fundamental differences of composition, with the added significance of differences of physiological function. Some of these consequences are easily brought to demonstration. Take a "Swedish" filter paper as a normal standard, serving as basis of comparison, and select a paper of each of the above classes, as used for writing or printing purposes. Such papers it must be premised contain a proportion of "sizing" constituents; that is, they consist of the respective celluloses with "organic" colloids, *e.g.*, gelatine or starch, and fatty or resinous bodies precipitated into the sheet from alkaline solutions by means of sulphate of alumina. These constituents, jointly and severally, contribute a certain water or ink-resisting quality, which we may define in precise terms as so controlling or limiting the absorption of aqueous solutions that it takes place in the vertical (downward) direction only. It is necessary to mention these qualifying or auxiliary constituents as they contribute directly to the effects we are about to describe. We have asked the reader to "select" papers of the typical classes; but on the assumption that he may probably be doing this for the first time some directions are required. There we meet a difficulty. It might occur to the layman that he has only to go to "the Shop," there to ask and to get. But stationers are notoriously stationary. Their classification of papers is strictly limited to such side issues as price, "get up," colour and so forth. The shopman's vision generally is limited by the horizon of values, that simple calculus of differences by which the

"steady three to two against the purchaser" is maintained; he seldom condescends to things. The best way out of this difficulty is to adopt a plan somewhat as follows:—

For a paper of Class I. your lawyer's letters will supply specimens: the lawyer knows the value of a letter both to himself and client! The profession knows no laws so binding as those of precedent and convention, and therefore it jealously conserves such papers as it has known through the ages, such also as it knows will preserve our "acts and deeds" for all time.

For Class II. look up letters from friends in Germany. The chances are several to one that these will be "cellulose" papers. Cellulose we must explain in German technology means "Wood Cellulose". The limitation is the basis of a small quarrel which we have with our cousins; we are getting the best of it and shall succeed in "depolarising" the term and restoring to it, even in Germany, its general significance.

For Class III. letters from members of the "lower middle class," or publications, we regret to say, of many of our learned Societies will supply specimens.

Having by these indirect means obtained authentic specimens they may be put through the following simple tests: (1) Place the specimens each in a stoppered bottle containing a few cc. of water. Set aside in a "warm corner" and after ten or fourteen days note what has happened. Papers of Class I. will have proved themselves an excellent nidus for micro-organisms of all types, colonies of these will have established themselves after their manner and gorgeous effects in yellow, crimson, and blue will reward the observer. The filter paper (which by the way must not be allowed to come in actual contact with the water) will not show any such effects. They are obviously due to the nitrogenous colloid, the gelatine, used in sizing the paper, for as regards the cellulose fibres of which they are composed the two papers may be considered as identical. Probably also the papers of Classes II. and III. will not have grown any organisms. In other words, the pure celluloses are not susceptible to the direct attack of organisms. But given a supply of the

necessary nitrogenous and saline nutrients they yield more or less readily in the inverse order of our classification. They yield, by undergoing hydrolysis to soluble products allied to the starch-sugar series, capable of assimilation by living organisms. The celluloses of the cereals and of esparto are very readily so attacked, and for this reason the tissue constituents of the straws are considerably digested in their passage through the digestive tract of the herbivora. Precisely for this reason the celluloses of straw or esparto rank very much below the normal or typical cotton cellulose, as paper-making materials. The wood celluloses are intermediate.

(2) The selected papers may be exposed to the heat of a water-oven and the effects noted from time to time. Such effects result in short time, as over lengthened periods of storage under ordinary conditions. Papers of Class III. will discolour very rapidly and at the same time become brittle. In regard to the action of dry heat again the papers will be found to range themselves according to our classification, as they have been found to do in reference to permanence under ordinary conditions. The changes determined by heating are not only chemical but structural: those physical properties upon which the qualities of the fibre-agglomerate depend, are in considerable measure properties of the fibre-substance itself, and as the constitution of the cellulose is changed under the joint influence of the temperature and the saline constitutents of the paper, there follow changes in breaking strain and elasticity.

As already explained it is not the purpose of this article to enter into a minute discussion of the technics of paper, nor do we think that in these days science needs to "labour" a case for the consideration of the lay-public nor should be compelled to come cap in hand to the manufacturer and beg to be allowed to show him how to increase his profits. That, by the way, is the one question which the scientific man does not allow to be a question at all. If the manufacturer wishes to accept the challenge of science, it must be somewhat in these terms:—

(1) As regards quantity: Can you account for every

pound of raw material taken into work? and (2) as regards quality (of manufactured product): Is this regulated by normal standards combined with systematic records? The above being the scientific conditions of routine production.

And then (3) as regards improvements and discoveries: Are you organised not only to take note of all forward movements from outside, but to ensure a proportionate probability of personally securing a lead in the large technical advances which are being made and to be made? The manufacturer, in other words, must seek first the kingdom of technology, and all the details of large profits will be duly added.

Our friend, the unconverted paper-maker, smiles. We know that smile. It is the smile of the man who would sleep a little longer.

And what of the consumer of paper? His name is legion and it is of little avail to work for a universal public opinion upon such a subject. We can only make our appeal to those who can mould or constitute such a stress of opinion or judgment as shall gradually bring about a reform which in other countries can be determined from the head-quarters of a parental government. It will be enough to convey to scientific men that there is a large field of useful and extremely interesting work to be done in bringing science to bear upon the vastly important industry of paper.

As for special problems, they are innumerable and the solutions are at hand.

To return to our "ideal" Bank of England note. We can produce that gelatine-free, *i.e.*, nitrogen-free; similarly our water-colour or drawing papers, our photographic papers, can be produced with at least this safeguard against mould and bacterial growth; our "Art papers" can be produced with something less than 30-40 per cent. of mineral matter or "filling," and we can make papers adapted to a hundred and one of the uses to which it is not as yet applied.

What a blessing that the absurd phrase *fin de siècle* has already begun to pass into the limbo of antiquities! Probably also in the next century we shall have no

"Baxterisms" to feed the catastrophic mind, and we shall start on a fair career of further industrial evolution. We convey the hint to those who are minded to play their part in this scheme that the subject of cellulose is worth attention. It can never be said of the cellulose industries that they are played out or ever likely to be. This by the way.

But we can commend our subject on other than grounds of personal enterprise, that is, on the basis of industrial ethics or morals. One of our thinkers wrote it down as a crime that a child should grow up uneducated. What are we to say to such ignorance of "things" as leads people to buy "linen" handkerchiefs for 2s. 6d. a dozen, to pay 4d. per lb. for soda ash—bought as "Diddler's Detergent"; ten shillings a lb. for permanganate of potash because sold as "I. Prices's Chameleozone," and to buy china clay at the rate of 1s. per five quires because it is called "paper"?

Is this the ignorance of the blissful order which 'twere folly to disturb? Is it in the code of natural science "criminal" as implying divorce from the realities of the world?

Whatever it may mean in the popular code, the scientific mind cannot see these things and pass by on the other side. It may be picturesque and may be amusing. But we need not adopt a close season for eccentricities and perversities for fear that intellectual sport will die out for want of game. There is a fresh supply of the more ignorant to reach maturity every day, and these are no doubt providentially supplied for the less ignorant to "operate" upon; also there is evidently a sublime law of the ridiculous. Therefore we may go forward and wage the battle of the paper standards. It cannot spoil sport nor do any honest man any harm and it will do science the good of extending its dominion to a most "legitimate" and desirable province.

C. F. Cross.

ON SELECTION IN MAN.

MY last article dealt with processes of human selection dependent on or connected with differences of colour: in the present one I propose briefly to discuss similar processes connected with differences of headform, and especially with dolichokephaly and brachykephaly. Colour yields the most conspicuous and in some respects, perhaps, even the most important of the signs of difference between varieties of mankind; but diversities of headform are generally believed to be more permanent, though this has never been absolutely proved.

The starting-point for investigations of this subject may be said to have been given by Durand de Gros; though, when he affirmed that in the Rouergue the heads of townsfolk were longer than those of peasants, he did not at first divine the cause of this phenomenon, but ascribed it to the operation of "media," of some subtle influence of environment. At a later period, indeed, he began to see the relevance of the principle of selection; but it was De Lapouge who first saw its pre-eminent importance, and who applied it generally, not only to urban and rural populations, but to the different strata of society and periods of history. Working in the south of France, with Montpelier for his centre, he showed that the modern population of that town, formerly much longer-headed than the peasantry of the Herault, was in the way of losing this characteristic; also that the Languedocian nobility of the sixteenth to the eighteenth century had been dolichokephalic in the midst of a short-headed peasantry; and that a similar difference prevailed in the eighteenth century between the upper and the lower class of citizens in Montpelier. Thus—

	Montpelier at present.	Montp. 18th Century. Upper Class.	Lower Class.	Peasants at present.	Seigneurs 17th and 18th Century.
Mean kephalic index (relative head-breadth) -	81	75	78	82	76½

Now the Herault is a comparatively rich and level region, with a population of very mixed race, yielding to the callipers mesokephalic and sub-brachykephalic indices, while the nobility, Gothic or Galatic in its original strain, may be taken to be mainly composed of the descendants of those who have raised themselves to wealth by ability and energy. But on its northern border is the Aveyron, a poor, rugged, elevated district, with a decidedly broad-headed population of the Alpine race or type. In accordance with the well-known rule in such cases, there is, and has long been, a constant stream of migration from the Aveyron to the Herault, to which the analogous districts of the Tarn and the Lozère also contribute.[1] A necessary result is a gradual and slow increase in the kephalic index of a city such as Montpelier, from the relative growth of the brachykephalic element. And this process would have been much more rapid but for the operation of a law, the discovery of which we owe to De Lapouge and Ammon, *viz.*, "the greater readiness to migrate of the dolichokephalic element in a mixed population," whence it comes to pass that the Aveyronese emigrants are not so broad-headed as the population they leave behind them, in the ratio of 84 to $85\frac{1}{2}$.

De Lapouge follows Gobineau in regarding the tall, blond, long-headed breed of Northern Europe (the Aryan race as some would call it, though I regard the term as inaccurate and objectionable) as the salt of the earth, the stirring, active, ambitious, independent, courageous, locomotive element of mankind; and it appears to be this character which is connoted by that projection of the occiput, which is more common in the inhabitants of these islands than in those of almost any other country.[2] "The

[1] The Aude, a comparatively long-headed district at the foot of the Pyrenees, also furnishes a contingent, but not large enough to counterbalance the Aveyronese.

[2] An English naturalist made an unexpected visit to Prof. Fitzinger, the eminent Viennese anthropologist. "Welcome!" said Fitzinger, "I don't know who you are; but I can see you are a Briton by the back of your head."

dolichokephal has great ambitions," says De Lapouge,[1] "and strives without ceasing to gratify them. He knows better how to gain than to keep riches. He dares everything; and his audacity ensures success. He fights for fighting's sake, but not without some idea of profit behind. Every land is his: the whole globe is his country. His intelligence varies from stupidity to genius. He is logical when it suits him, and not to be put off with words. Progress is his greatest need. In religion he is Protestant; from the State he only demands freedom of action, and seeks rather to elevate himself than to depress others."

The other type with which we have most to do is the brachykephalic Alpine, sometimes, but perhaps inaccurately, called Kelto-slav.[2] In this the stature is short, the head is round or trapezoidal, flattened behind, the coloration brown or dark. "The brachykephal is frugal, laborious, or at least economical, remarkably prudent, and though not cowardly, yet not warlike. His intelligence is usually mediocre, and he works out patiently his limited ideals. Though suspicious, he is easily taken in with words. He is the slave of tradition, and of what is called common sense. He distrusts progress, and adores uniformity. In religion he is willingly Catholic: in politics, he has but one hope, the protection of the State, and but one tendency, to level down, caring little to elevate himself. He sees clearly his own immediate interest and that of his family and neighbours, but that of his country is too remote for him."

In the mixed breeds which largely prevail in France, "the egotism is reinforced by the energetic individualism of the dolichokephal, and the sentiment of family and of race is weakened: hence come the vices of which our bourgeois are accused, winding up with elimination by 'self-restraint'".

We all know that while dolichokephaly, even of extreme degree, prevails among the relics of the palæolithic

[1] I have somewhat abridged this very complete and coherent portrait, as well as that of Homo Alpinus, which follows.

[2] The brachykephaly of the earliest known Slavs is very doubtful, to say the most of it.

and even of the neolithic period, brachykephaly is extremely uncommon. Nevertheless it does occur; but still more seldom does it appear in an extreme form. Most of us are of opinion that the ancestors of the modern "Alpine" brachykephals were neighbours of the Iranian Galchas, and pushed westwards into Europe during the neolithic period, possibly bringing with them some twigs of the Mongoloid stem, and incorporating any western brachykephals whom they met with. Also we think that the paucity of remains of this race in the later prehistoric or earlier historical periods may have been due to their position as serfs to the higher race, which excluded them from elaborate modes of sepulture. But Lapouge takes another view, which I believe to be original. He thinks we have no grounds for believing in such a westerly migration: he would derive the modern from the prehistoric western shortheads, and explain their rarity in tombs simply by their relative paucity in the populations. That paucity, he thinks, may have grown into multitude by the action of such processes of selection and elimination as he and Ammon have found and demonstrated as operating at the present day. In a word, he rejects, like Lyell, hypotheses of catastrophe.

What these processes are may perhaps be best seen in the work of Ammon. The material of this was gotten by observation of the conscripts and scholars of the Grand Duchy of Baden, especially those of the cities of Karlsruhe, Mannheim and Freiburg-in-Brisgau; and when gotten it was subjected to analysis of the most masterly, minute and multifarious character. For some of his purposes and conclusions this material was ample; for others perhaps scarcely so. It may be necessary here to point out that for the determination of a question of head-breadth a much smaller number of cases, or of individuals, is sufficient, than for that of a question of colour or complexion. In the former case, as a rule, most of the knowledge sought can be acquired by simply dividing the material into the two classes of long and short heads. In the latter little can be learned, generally speaking, without dividing the material into a large number of classes. Thus Virchow, in his

inquiry into the colours of the German schoolchildren, made use of twenty-one categories: I, myself, always use at least fifteen. Unless, therefore, the aggregate number of specimens examined is very large, the numbers in the least populous categories come to be so small as to depend very much on chance.

To explain Ammon's methods it is almost necessary to reproduce one or two of his tables:—

FREIBURG CONSCRIPTS.

Origin of Subjects.	Kephalic Index.	Mean Head-length.	Mean Head-breadth.
Mean of surrounding district -	83·6	182	153
Immigrants, born in the Duchy -	83	184	154
Half-citizens (father country-born)	82	185	152
Citizens (father city-born) - -	80·8	187	151

Here the man who is attracted to the city has on the average a head longer both actually and relatively to its breadth than the peasant whom he leaves behind him. He is the product of a selective process. But an analogous process would seem to go on after his arrival. The dolichokephal is not only attracted by the city; he is in some way more suited to a city life. The broader-headed among his immigrant comrades seem either to return unsuccessful to the country or to fail in rearing progeny in the city.

Though the competitive struggle in these South German cities may be in some respects more severe than in the rural districts, it would seem that the whole urban population is better nourished than the peasantry. Ammon at least always takes this for granted in his arguments; and it is confirmed by the fact that the city-born youth, at the age of conscription, are taller than the country-born, though, as the former are clearly much more forward in the development of the physical signs of manhood, it is almost certain that growth continues in the latter to a later period. Doubtless here also the influence of some kinds of selection enters into the problem.

These conditions are not identical with those which

obtain in our own country. With us it is, as a rule, the lower-class youth of the cities who are worst fed, and their stature is below that of the same class in the rural districts.

The following table, for Karlsruhe, confirms almost absolutely the one for Freiburg.

KARLSRUHE CONSCRIPTS.

	Kephalic Index.	Mean Head-length.	Mean Head-breadth.
Mean of surrounding district -	83	184	154
Immigrants, born in the Duchy -	83·1	184	154
,, born elsewhere -	82·5	186	154
Half-citizens (father country-born)	81·5	186	153
Citizens (father city-born) - -	81·4	186	153
Do, native (father from another town) - - - - -	80·2	184	149
Both subject and father from another town - - - -	81·8	185	152
Born in a town (father countryman)	80·3	184	151
Born in country (father in town) -	82·8	184	153

These facts may be put in another form, in which they are perhaps still more striking.

	Average of Baden.	KARLSRUHE. Immigrants.	Half-cits.	Citizens.
Per cent. of indices below 80 (dolichoid)	12·2	14·9	25·9	33·3
Per cent. of indices of 85 and above - -	38·2	33·3	18·4	12·4

We are now prepared to receive as at least highly probable the "law of Ammon". "That in regions where the brachykephalic type prevails it tends to become localised in the rural districts, while the dolichoid type becomes concentrated in the cities." But if it need confirmation, this may be derived in abundance from the observations of Collignon, but more especially from those of De Laponge. Thus in a series of 108 immigrants into the Herault, the latter found an average breadth-index of 82·34, whereas the average calculated from the known indices of the several departments of origin would have been 83·40. Again, in four little towns of the Herault the urbans (issue of parents

both born in the towns) gave indices, Clermont of 79·5, Lodève of 79·7, Limel and Marsillarges of 82·1 and 81·3, while the corresponding rustics gave 84·4, 82·3, and 83·3. And in quite another part of France, De Lapouge found an index of 82·8 in 67 pure urbans of Rennes, but one of 84·7 in 100 country-folk of the circumjacent canton. In Bordeaux and eight other cities of the south-west Collignon found that the average difference of index between the town and the country was about two units, at Bordeaux itself 2·3. Lower Austria, again, is a moderately brachykephalic province, with an index of 82·2 and 25 per cent. of dolichokephals: Vienna yields 81·2 and 37 per cent., its suburbs 81·5 and 32, and country villages 83·8 and 10. Here we have, I think, a pretty distinct case of the selection of a race-type; for many years ago I formed the opinion tha tthe native Viennese were much more Germanic than the surrounding country-folk, among whom features possibly dating from the Avar occupation frequently cropped up. In connection with this "law of Ammon" several other "laws" have been laid down, chiefly by De Lapouge. One of these is the "law of altitudes" according to which, "in regions inhabited jointly by *Homo Europæus* (the dolichokephal) and *Homo Alpinus*, the former is concentrated in the lower levels". Facts illustrative of this law are so conspicuous that Johannes Rauke some years ago seemed inclined to think that an elevated habitat did in some way favour the production of a short-headed race. That is, of course, highly improbable; and it may be noted that very high averages of brachykephaly are found in some very level and lowlying regions, such as Poland, and Kostroma in Russia. Moreover, the rule does not hold good in southern Italy, where the two races in contact are the Alpine and (not the European but) the Mediterranean dolichokephal. Still, it is of very wide application and by no means confined to Europe. The causes are partly political, partly selective. A conquering tribe seizes first the territories least easy to defend, and retains for itself the most fertile lands—these are usually identical, and lie in the plains rather than in the hills; moreover, the conquering

races of Europe have almost all belonged to the dolicho-blond type.

Law of Distribution of Wealth.—In countries inhabited jointly by *Homo Europaeus* and *Homo Alpinus*, the former element possesses more than its proportionate share of wealth. This law is connected with the last through an intermediate one, *viz.*, that great cities are generally found in dolichokephalic or comparatively dolichokephalic regions, *i.e.*, in the plains; and on the other hand is related to the law of Ammon, because, as we have seen, the dolichoid element tends to concentrate itself in the cities. The test of this rule is tax-paying capacity. De Laponge has compared the thirteen most dolichoid departments of France with the thirty most brachykephalic. The latter are the more extensive and thinly peopled: each group contains about 10,000,000 inhabitants. I have abridged and simplified his table.

		Dolichoid Group.	Brachy Group.
Taxes on Land - - -	proportion to	100	168
„ Personal Property -	„	100	50
„ Doors and Windows -	„	100	50
„ Transfer of Property -	„	100	56
„ Bequests and Inheritances	„	100	48
„ Leases and Mortgages	„	100	40
„ Stamps - - -	„	100	40
„ Beverages - -	„	100	43
„ Tobacco - - -	„	100	68
„ Bicycles - - -	„	100	60
Receipts of Departments - -	„	100	90
„ Communes - -	„	100	27
Octroi - - - - -	„	100	15
Indebtedness of Communes -	„	100	16

The excess on the brachykephalic side of the tax on land (unimproved property) is due to the greater area included. The dolichoid group is evidently the more active, wealthy, commercial, industrious, luxurious; financial needs are greater, whence larger public debts.

This table may be tested to some extent by the following statistics from Italy:—

	Northern Italy Provinces.		Southern Italy Provinces.	
	11 most br.	13 most dol. (or least br.).	11 most br.	10 most dol.
Population	4,680,000	4,516,000	5,022,000	5,038,000
Taxes on Land - -	100	64	101	81
„ Buildings -	100	131	85	88
„ Personal Property	100	149	58	59
Inheritance Tax - -	100	97	50	59
Registration Fees - -	100	105	87	91
Totals, allowing for differences in population -	100	113	71	68
Totals, excluding Land-tax	100	132	64	67

Here the comparison is fairer in one respect; every one of these divisions, except the third, contains several large towns. The dolichoid element in the second consists largely of the northern dolichoblond race; that present in the fourth, and to a less extent in the third, is pretty purely Mediterranean; and in this race the leading qualities of the dolichoblond are not supposed to be highly developed. The attachment of the brachykephal to the land seems to be shadowed in the large proportion it bears in his districts to other kinds of property.

Ammon finds that a natural selective process continues to work among citizens, so that the longheads gradually rise towards the higher social strata. Thus in the higher schools the proportion of longheads is very large.[1] And in thirty intellectual men, members of a scientific society, he found an index of 80·8, while twelve of the most distinguished yielded one of 79·6, the lowest mentioned in his book. These low indices result from increased length, not from decreased breadth.

Against this observation of Ammon's must, however, be placed that of Houzé of Brussels, who found that in thirty

[1] It will be remembered that Dr. Venn's extensive observations showed that first-class men at Cambridge were longer-headed than second-class men, and they again than the simple pass men and the failures. Muffang of St. Brieuc finds that in schools the dolichoids do best on the modern side, the brachys on the classical. And there is some other evidence for this.

men of good intellectual standing the heads were broader on the average by two or three degrees than those of the lower classes in that city. This part of the subject requires more elaboration.

Athletes (fifty-two members of athletic clubs) were a selection in the dolicho-blond direction, *i.e.*, in the direction of the true old Germanic type, the average index in ten purely citizen athletes being only 80·5, and their heads being absolutely as well as relatively long, criminals (sixty at Freiburg), were a selection to some extent in the other direction, but not so distinctly. The kephalic index was normal, but the head small, the skin dark, and brown eyes and brown hair in excess.

Another class studied by Ammon was that of clerical students. He found them decidedly short-headed; but as they are drawn for the most part from the peasantry this is what might have been expected.

Phenomena of colour have been almost or quite as carefully studied by Ammon as those of headform, but not with quite so distinct or valuable results. In general the numbers are not large enough to give anything better than a moderate degree of probability. On the whole, the blond type increases relatively with city pedigree and the brown type decreases, but this is more distinct with regard to the eyes than to the hair. The pure blond type of Virchow (blue eyes, blond hair, fair skin) certainly increases in the conscripts; so it does in the "Realschulen," while dark hair, though not dark eyes, increases in the gymnasia. These results are difficult to reconcile with the facts which I have given in a former paper, as to the deeper coloration of both eyes and hair in German cities compared with the surrounding rural districts. Perhaps both the fair Germanic and the dark Mediterranean type (which latter, however imported, does seem to be present in the Rhine Valley) may be more favoured than the brown brachykephalic one, in the struggle for survival as carried on in these cities, while mixed forms, resulting from the crossing of incongruous types, together with neutral eyes and round heads, are more likely to be worsted and thrown out.

It must never be forgotten that the conditions under which problems of this sort arise in England are quite different, owing to the comparative weakness[1] in this country of the brachykephalic, and the greater strength of the Iberian or dark long-headed element. The same may be said of Spain and Portugal and Southern Italy; while in Scandinavia the dolichoblond type prevails still more exclusively. Hence most of the anthropo-sociological investigations hitherto undertaken in this country have been more or less barren, at least those based on the diversities of the kephalic index. Thus I got for the citizens of Bristol an index identical to a fraction with that of the natives of the surrounding counties; nor do I find that the higher or educated class differs materially, *in this particular point*, from the proletariat.

Returning, however, to the middle zone of Europe and the Alpine race or type, we find further and very curious evidence to the migratory instinct of the dolichoid element. Thus De Laponge lays it down that "the kephalic index of the children of parents belonging to two different districts is lower than the mean between the indices of these districts"; or, which amounts to the same thing, that "the dolichokephal members of a community are more apt than are the brachykephal members, to choose their spouses outside of their own birthplace". This he tests by comparing the index of subjects whose parents were born in one and the same canton with that of subjects whose parents were born in different cantons. These he calls cantonaux and intercantonaux. In the Herault, with a large amount of material, he finds the index of the former to be 81·5, that of the latter 79·8. A number of small series in other parts of France give analogous results; and the law seems to be true of departments as well as of cantons, two small series of them giving contrasts of 82·9-81·1 and 83·2-82·3.

All the processes and tendencies we have been reviewing, and others which have been left unmentioned because less important or less certain, may be grouped together

[1] De Lapouge says "absence," but that is too strong a term.

under one law, which Closson has most fitly styled "the Law of Lapouge," *i.e.*, that of the greater activity of *Homo Europæus*.

Whether we can conceive of the ultimate results of all this as being in agreement with the Darwinian law of the survival of the fittest, unless we are careful to ascribe only the absolutely correct meaning to the word fit, is a little doubtful. The dolichoblond man was developed, we believe, in the course of a long and arduous struggle against the hostile powers of nature, as well as against his fellow-man. Beowulf and Siegfried and Hercules were his ideals. Now perhaps he may not be quite so much needed. Most of the processes we have reviewed may seem to turn to his advantage, but this is not so in the long run. Most of the great things that have been done in the world, it is said, have been done by him;[1] but in doing them, or in consequence of doing them, he and his progeny are very apt to perish. How few descendants can be found of great soldiers, travellers, discoverers, inventors, poets. The higher and more enlightened classes in communities, the producers and assimilators of new ideas, have repeatedly in the course of history been swept away or decimated, while the proletariat survived. Thus the noble Greek race, which was long-headed and largely blond, has now but few and doubtful representatives; the Ostrogoths, a people evidently of great capacities, almost wholly perished; the nobler strains of the Irish people perished or emigrated in the seventeenth century. And now-a-days, in the cities of France and central Europe, the dolichoids seem to melt away, to give place to fresh strains of brachykephalic peasant blood. The fittest, who survives, is therefore the quiet, unambitious, commonplace thickhead, who remains at home and tempts no dangers. It may be that when wars have ceased to be and there are no more regions to explore, and perhaps fewer scientific realms to conquer, this may be the happiest as well as the fittest, *i.e.*, the best adapted class of man. It certainly seems most suited to a socialist organisation.

[1] Napoleon, however, though blue-eyed and rather blond than dark in hair, was decidedly brachykephalic.

Or again, as cities become more healthy, and rural districts less peopled, it may be that the type we call Mediterrean or Iberian, the long-headed dark type may, as Ammon seems to expect, acquire a numerical preponderance.

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JOHN BEDDOE.

THE ZEEMAN EFFECT AND DISPERSION.

A GOOD many years ago, as the years of scientific discovery in the nineteenth century are counted, Faraday observed an action of magnetism on Light. He observed that when a beam of plane polarised light is transmitted through a transparent solid along the direction of a magnetic field in which the solid is placed, the plane of polarisation is rotated. This action of matter when magnetised upon light may be described as due to its transmitting a beam of right-handed circularly polarised light at a different rate from a left-handed beam. This difference of rate of transmission is an extremely small part of the whole rate. The rotation of the plane of polarisation is a very delicate test for a difference between the rate of propagation of the right- and of the left-handed beam. For example, we may suppose a substance such that, after passing through one centimeter of it in a certain magnetic field, the plane of polarisation is rotated through a right angle. It would require a *very* strong magnetic field to produce this effect with the most active transparent body known. Yet the change in the rate of propagation involved would be very small even in this case. A rotation of the plane of polarisation through a right angle would require one of the circularly polarised beams to gain one-half wave length over the other in going through a centimeter. As there are some 17,000 wave lengths in a centimeter of air and in the dense media that are magnetically active about 30,000, it is evident that a gain of a half wave length per centimeter means a difference of rate of propagation of only one 60,000th part of the velocity. In most cases the rotation per centimeter is very very much less than this, so that in these cases the phenomenon is due to a very much smaller action between the magnetised medium and light.

It is to be observed that this action is an indirect one. It is not an action of magnetic force directly on light. It is an action of magnetic force on matter, and of the

magnetised matter on the light. Magnetic force changes matter in some way owing to which the magnetised matter transmits right- and left-handed circularly polarised beams at different rates along the direction of magnetisation. Without matter there is no known action of magnetic force on light. Another thing to be observed is that the action is negligible for very long ether waves and only becomes of importance for the short waves which are in the neighbourhood of the visible part of the spectrum. The phenomenon is much more closely allied to dispersion than to refraction. The longest ether waves are not propagated at the same rate in matter as in free ether, they are largely refracted. Long ether waves are, however, all propagated at nearly the same rate. The differences of rate of propagation that produce the phenomena of ordinary dispersion are only of importance in the case of the short waves which are in the neighbourhood of the visible part of the spectrum. In the case of both the effect Faraday observed, and of dispersion, the action is roughly inversely proportional to the square of the wave length, thus leading one naturally to expect that they may be allied phenomena.

If, with this clue, we were to seek for some explanation of the Faraday effect we should study the various theories that have been propounded to explain dispersion. The oldest of these explains dispersion by the hypothesis that the distances between the molecules of matter are comparable with the lengths of the waves of light. In the case of wave lengths, for which this is true, there must exist dispersion phenomena, and until some rough estimate had been made of the distances between molecules of matter there seemed good reason to suppose that the phenomena of ordinary dispersion were due to this cause. The theory explained the laws of ordinary dispersion as well as could be expected from a rough theory, which took no account of the structure of the molecules themselves. Now, however, it is known that the distances between the molecules in transparent solids is a great deal too small to explain ordinary dispersion. Dispersion due to this cause must be concerned with waves of very much shorter wave length

than any that have been satisfactorily measured; perhaps some phenomena may be observed in reference to Becquerell or X rays depending on their wave lengths being comparable to the distances between molecules in solids. Hence it is not in the direction of this theory that we should expect to find an explanation of the Faraday effect.

The theory of dispersion that seems to explain very satisfactorily the phenomena is one that attributes it to a comparability between the frequency of vibration of the light and of the atoms of matter: to a resonance of the matter to the vibrations of the light passing through it. It is not very easy to put the dynamical basis of this theory in general terms in a simple manner. The phenomena of forced vibrations are not familiar to most persons, and it would take a long explanation to bring the matter clearly before those not already familiar with these phenomena. The part of the phenomena on which ordinary dispersion depends might be illustrated by the following experiment. Suppose a long chain stretched between two points. We are all familiar with the way in which a wave can be propagated along such a chain. The rate of propagation is independent of the length of the wave so long as it is not comparable in length with the links of the chain. If the links have masses of lead attached to them the result will be that these long waves will all be propagated more slowly than before, but all the same amount more slowly. This may be taken as analogous to the slower propagation of light in transparent matter than in free ether. It will complicate this simple result if the leaden masses, instead of being simple masses each firmly attached to a link, are each made up of two masses fastened together by a spring so as to be capable of vibrating independently of the links. The effective inertia of these double masses will be the same as if they were rigidly fastened together so long as the vibrations of the links are very slow compared with the independent vibrations of the double masses due to their parts being connected by springs. When the links vibrate slowly the double masses will move together, and there will be very little motion of one of their parts relatively to the

other. When, however, the frequency of vibration of the links is at all comparable with the frequency of relative vibration of the parts of each double mass these parts will be more or less violently agitated, and there will be a considerable relative motion of the parts of each double mass with a straining of the spring connection between them. The effective inertia of the double masses in this case is quite different from what it is when there is no internal relative motion of their parts. The general result is that when the frequency of vibration of the links is less than that of the double masses a wave is propagated more and more slowly the more nearly the two frequencies approach coincidence. When the frequencies coincide ordinary wave propagation ceases in the theoretical case, as all the energy is spent in increasing indefinitely the internal vibrations of double masses. In considering the case of ordinary dispersion we need not look into the matter further. Ordinary dispersion consists in the propagation of waves of great frequency being slower than that of waves of smaller frequencies, and it is easy to see how the above-mentioned analogy illustrates this phenomenon. We must suppose the atoms of matter immersed in the ether capable of internal vibration at a frequency somewhat greater than that of the light we are studying, and then we might expect the waves of frequencies approaching those of the atoms to be propagated more slowly than waves of slower frequencies which do not agree so nearly with that of the atoms. Two things will determine the amount by which the matter will alter the velocity of propagation of the light. One will be the amount of interconnection between the matter and the ether. We might naturally expect some kinds of matter to be only very slightly acted on by the vibrations of the ether in which it is immersed, while other kinds of matter would be much acted on by these vibrations. The reaction of the matter on the ether and on the rate of light propagation would be in the first case small, and in the second case large: the first kind of matter would generally be more highly refractive and dispersive than the second. The other thing that will determine the amount of dispersion

will be the nearness of the frequency of vibration of the atom to the frequencies of vibration of the waves we are studying. If the atom frequency is only a little greater than that of the waves its effect upon them will be great, and the velocity of propagation of the waves will be slower than if the atom vibration were of much greater frequency than that of the waves.

That atoms of matter can vibrate at frequencies somewhat greater than those concerned in the light we use when studying dispersion is manifest from the spectra they exhibit. The very great opacity of all known transparent substances, even of gases, to ultra-violet light of frequencies of vibration not very much greater than the frequencies usually studied proves that all these bodies are capable of absorbing vibrations of the frequency of these ultra-violet vibrations, and are, consequently, capable of themselves vibrating at these frequencies. There is, consequently, no objection such as could be urged against the other theory of dispersion to this, what may be called, resonant theory of dispersion. In one case the two theories run into one another to some extent. When masses are regularly distributed through a medium, we may consider the medium between any pair of masses as capable of independent vibration : it could, in general, vibrate with a node at each mass and a set of intervening loops. The slowest of these rates of vibration would be comparable with that of a wave whose length was double the distance between the masses so that we might consider the phenomenon as due either to a comparability of the wave lengths to the distances between the masses, or to a comparability of the frequencies to the frequencies of vibration of the medium between the masses. The subject does not seem of much immediate interest, however, as phenomena depending on these very short waves have not been sufficiently studied to be capable of discussion in connection with a theory of this kind.

It is evident, then, that anything which alters the vibration frequencies of the atoms of matter must alter dispersion. Altering the density of matter will also, of course, alter the rate of propagation of light: it will alter the grip that

the matter has on the ether. Hence there are two ways of altering the rate of wave propagation, one by altering the amount of connection between the ether and matter, and the other by altering the frequency of vibration of the matter. For example, by increasing the density of a gas we must reduce the velocity of propagation of light through it both because there is more matter acting on the ether and because, as has been shown, the rate of vibration of the molecules is reduced and thus the frequencies of vibration of the ultra-violet vibrations that control dispersion are brought into closer coincidence with the visible radiations and this makes the rate of propagation of these latter slower. This latter effect has not been observed owing to its extreme minuteness. There may also be other effects on the waves due to other changes in the vibrations produced by the increased density. For example, it has been shown that there are certain absorption bands in oxygen whose intensity depends on the square of the density of the gas. They are consequently, in all probability, due to vibrations which are only executed during the collisions of the molecules, and if the vibrations that control dispersion are in any sensible degree of this character, there may be a corresponding reduction of velocity of propagation of light through oxygen depending on the square of its density.

One of the best known methods of observing these changes in velocity of propagation due to changes of structure is by observing with polarised light the crystalline structure produced by straining transparent solids. In this case, as in that of crystalline structure in general, the rates of propagation of vibrations executed in different directions are different. This may be due either to the interconnection of the matter and ether in different directions differing, or to the frequencies of vibration of the molecules in different directions differing, or to both these causes. On account of the want of sharpness of the absorption bands in solids it would not be easy to observe the probably very small change in their position due to straining a solid, so that it does not seem probable that we can in the near future distinguish between the two causes in the case of solids as we

seem already almost in a position to do in the case of some gases. The dichröism of some crystals makes it possible that some at least of their double refraction may be due to a difference of frequency of the vibrations that control dispersion in different directions.

The question thus arises whether we cannot, in accordance with their principles, explain the differing rates of propagation of right- and left-handed circularly polarised light that Faraday observed to exist in matter in a magnetic field. This Faraday effect might be due to one or other of two causes. Either the magnetic field might cause a greater interconnection between the matter and the ether for one of the circularly polarised vibrations than for the other, or it might cause the molecules that are vibrating round in one direction to have their frequency increased while the frequency of those vibrating round in the other direction was decreased. Either of these causes would explain the Faraday effect. The first of these is the kind of effect we might expect to be produced by that action of magnetic force on matter by which it is supposed to orientate the molecules. This is the generally accepted cause of paramagnetism and the Faraday effects in paramagnetic bodies are sufficiently different from those in diamagnetic bodies for it to be probable that their cause is somewhat different. From this point of view it would seem natural to conclude that in diamagnetic bodies magnetic force had the power of altering the rates of vibration of the molecules and causing the right-handed circularly polarised component rotating round the lines of magnetic force to be executed at a different frequency from that of the left-handed component. It is well to consider these right- and left-handed circular vibrations as components of a more general vibration because it is improbable that the actual vibration in any one molecule is an accurately circular motion. It may also be worth while pointing out that the result of compounding two equal circular vibrations in the same plane, but of slightly different frequencies is to produce a linear vibration whose line of vibration rotates in the plane of the two circular vibrations. Hence we might describe the effect

we have supposed magnetic force to have on the vibrations as being a rotation of all linear vibrations round the lines of magnetic force, or a precessional rotation of the axes of the vibration, in the case of non-linear vibrations. Lorentz has pointed out that if the vibrations in matter that are connected with the ether are due to the motions of electrons, this very precessional motion is what might be expected from the disturbance of the orbits of the electrons by the magnetic force. We may then reasonably expect that magnetic force does make the right-handed circular component of the vibrating molecules to rotate at a different frequency from the left-handed component, these components rotating round the lines of magnetic force. Hence, one of these components in the ultra-violet vibration that controls disperson will become more nearly of the same frequency as that of visible light and so will cause the corresponding circular component of the visible light to be propagated more slowly than the oppositely rotating component,—for this latter will be less in accord with its corresponding vibrations in the molecules when magnetised than when there was no magnetic force acting, and so will be less affected by them. Hence there would seem to be every reason for attributing the Faraday effect in diamagnetic bodies to such a change in the vibrations of the molecules as has been described. When we consider the observed direction of the Faraday effect in diamagnetic bodies we find that in order to explain it by Lorentz's theory we must assume that the connection between matter vibrations and the ether is principally due to the motion of a *negative* electron. This is no doubt a very remarkable deduction from the theory, but some phenomena of vacuum tube discharges seem to imply that the negative electron is more free to move about than the positive electron. This may all be due to some essentially positive characteristic of the matter in our part of the universe. The accumulation of matter of the same kind in one system being possibly produced by its gravitational repulsion for matter of the negative character.

And now what independent evidence is there that magnetic force can influence the vibrations of molecules?

Faraday looked for this and Zeeman found it. The direct observation of an alteration in the vibrations of molecules by magnetic force is one of the most interesting and important observations made of recent years. It is most interesting and important for several reasons. It enables us to study the internal vibrations of molecules by modifying in a simple way the conditions under which these vibrations are executed. The laws of action of magnetic force are so well known that we can be fairly sure how it acts on the molecular motions and from a study of the effects produced we can already make inferences as to the nature of those motions in the molecules to which the spectral lines are due. For example, the hypothesis has received confirmation that the lines are due to the motions of electric charges, and there seems reason to suppose that these electric charges are accompanied in their motions by only a small part of the mass of the molecule. Further, we are now able for the first time to produce polarised radiations from the molecules of a gas. Hertz showed how to produce polarised radiations from electromagnetic oscillations on conductors, but hitherto attempts to produce polarised radiations from gaseous molecules have failed. This is in itself a great advance in our means of studying these vibrations : it simplifies the problem to be studied by analysing it into components. We know that different lines in each spectrum have different physical characteristics such as belonging to different so-called series of lines, being reversed with more or less ease, becoming more or less expanded, etc., under changes of temperature and pressure and we are now provided with a further characteristic difference between lines in that they are differently acted on by magnetic force.

The effect of magnetic force on the vibrations of molecules is a complicated one. The apparently simplest effect upon a vibration is to produce the result already described as required in order to explain the Faraday effect and which Lorentz has taught us we should expect to be produced on a vibrating electron. Every simple vibration of a point may be analysed into two circular rotations, one right- and the other left-handed, in a plane at right angles to the magnetic

field and into a linear component in the direction of the field, all these being of the same period. The effect of the magnetic force in the simplest and apparently very common case is to leave the component in the direction of the field unchanged and to make one of the circular components rotate more rapidly and the other less rapidly than when there is no magnetic force acting. The changes of frequency are directly proportional to the strength of the magnetic field, but are independent of the intensity of the vibration of the molecule. This simplest action is what we would expect to take place when the magnetic force acts on a moving electron which is equally free to vibrate in every direction. On account of this important condition, however, we need not be surprised to find more complicated effects produced in the case of a large number of spectral lines. It is very improbable that the molecules of most gases are so symmetrical that all vibrations in every direction are equally possible, and, as a matter of fact, very complicated effects have been observed in the case of a large number of lines. The effect of magnetic force in this simplest case is to make the axis of the orbit of an electron rotate round the line of magnetic force. We might expect a disturbing force to produce other changes in the orbit, in general; such, for example, as causing the inclination of the orbit and its eccentricity to change. Actions such as this would produce complications in the spectra, as has some time ago been pointed out by Dr. Stoney.

These theories as to light vibrations being due to simple harmonic vibrations of electrons are, however, almost certainly only provisional. They require the forces acting on the electrons to be directly proportional to the distance from their positions of equilibrium. It is unlikely that electrons can be subject to such forces and their vibrations are much more probably of the nature of perturbations of orbital motions executed under quite other laws of force. For example, the rotation of the lunar nodes is a vibration of, a system, the earth, sun, and moon, which is controlled by forces varying inversely as the square of the distance and is one whose period is almost independent of the eccentricity of

the lunar orbit although the amplitude of the radiation such a rotation might emit might be directly proportional to this eccentricity. The whole question is very complicated. It practically assumes that the fundamental motions in the molecules are immensely more rapid than any of those we deal with in light vibrations, and that these latter are merely perturbations of the fundamental motions. It is well to keep these things in mind, although we are to all appearance so very far from any satisfactory explanation of it all, because it points out the direction in which to look for an advance in our knowledge. That we know so little and see so little ahead in these fundamental matters may be disheartening, but it shows how very important any advance in our knowledge of molecular motions is and should encourage us to a study of even minute effects such as Zeeman has observed.

In the simple case referred to above, the radiation emitted under the action of magnetic force, when studied by a spectroscope, has the following characteristics: the radiation emitted along the lines of magnetic force consists of two circularly polarised beams, one right- and the other left-handed, vibrating at slightly different rates. This is exactly what might be expected to be emitted from an electron moving in the way already described. The component of the vibration along the lines of force would not give rise to any sensible disturbance at a distance along that line, and the two circular components of its vibration in the plane at right angles to the force would produce the observed circularly polarised beams. The effect of the magnetic force on a spectral line which is thus simply affected is, when viewed along the lines of force, to double the line, one of the components being right-handed and the other left-handed circularly polarised light.

The radiation emitted in directions at right angles to the magnetic force is most simply described as consisting of three beams. One due to the component along the lines of force whose frequency is unchanged, and which produces a plane polarised beam and resulting line in the spectrum in the same place as when there is no magnetic force acting; and two other beams due to the two circular components

whose frequencies are one greater and the other less than that of the unchanged vibration. The radiations emitted by these circular components in the plane of their motion are plane polarised in a plane at right angles to the unchanged one. The effect observed in the spectroscope is the production of two lines, one on each side of the unchanged one, and both plane polarised in a plane at right angles to that of this unchanged one. Further, on considering the direction of rotation of the circularly polarised beams emitted along the lines of magnetic force, it can be shown that the beams must be principally due to the rotation of a negative electron.

All this direct observation of the effect of magnetic force on the vibrations of molecules confirms the theory already expounded as to what ought to take place in order that we might explain the Faraday effect by a resonant theory of dispersion. It proves that there really exists the action of magnetism on the vibrations of the molecules that that theory postulated, and consequently proves that here is a *vera causa* for *a* Faraday effect. All that is further required is to show that it is a sufficient cause for the observed Faraday effect. Unfortunately the data required for this confirmation of the theory are not available. We should know, in the case of at least one gas, the amount of the Faraday effect, of the Zeeman effect, and in addition the law of dispersion by the gas sufficiently accurately to calculate the frequency of the principal absorption that controls its dispersion. The Zeeman effect and Faraday effect have not been measured in the same gas. Besides this, the Zeeman effect is not the same for the various lines in a single spectrum, and we know no law for calculating its effects on one line from observations on another. What we require in our calculation is the Zeeman effect on the absorption band that controls dispersion, and this has not been observed in any gas, the band being far up in the ultra-violet. For these reasons there is little prospect of any except a very rough comparison between theory and experiment being possible for some time. When we make a rough estimate of the possible Faraday effect from the observed amounts of the

Zeeman effect in the substances already studied and from the observed dispersion in air, we find that it is of about the amount that has been observed for the Faraday effect in air. So far, then, it appears probable that the whole cause of the Faraday effect is to be looked for in each substance in a Zeeman change of the free vibrations of the molecules of the substance by the action of magnetic force, this change in the free periods reacting through their resonances on the rate of propagation of the circularly polarised components of light passing through the magnetised medium.

A theory on similar lines may be worked out to explain the Kerr effect and the Hall effect: this latter being an action on electrons moving continuously in one direction, not on simply vibrating ones. This has been gone into by Mr. Larmor in his valuable papers on Electromagnetic Theory in recent volumes of the *Phil. Trans.*

A very interesting and fundamental question is raised by all this theory as to the cause of the Faraday effect when we compare it with former theories as to its cause. Former theories all attributed it to a gyrostatic action accompanying propagation of waves along lines of magnetic force. The illustrations of magnetic rotation of plane of polarisation have all been derived from the propagation of waves through media in which rotating gyroscopes played the part of the magnisation of the matter. It is, in fact, impossible not to fall back directly or indirectly upon a rotation when we look for an explanation of the Faraday effect upon dynamical principles. Yet, where, in the theory here profounded, is any rotation postulated or gyrostatic action involved? The action of magnetic force on a moving electron, which is postulated to be the same as on an electric current, does not appear at first sight to involve gyrostatic actions. Yet the whole theory given depends on this action and on dynamical effects which do not in any way involve gyrostatic effects. Mr. Larmor, for example, supposes magnetic force to be due to an irrotational flow in the ether and an electron to be a singular point surrounded by a peculiar condition of twist. Where in this is

any gyrostatic action postulated? Apparently nowhere. When, however, we look further into the matter, we find that even in Mr. Larmor's theory a gyrostatic effect is introduced in order to explain the properties of his ether upon ordinary dynamical principles. His ether is supposed capable of elastic reaction to *absolute* twist. This is only to be explained on ordinary dynamical principles by attributing to the ether gyrostatic properties due to some of its parts being in rapid rotation. It would appear, then, that, if not directly, at all events, indirectly, the phenomenon of the rotation of the plane of polarisation of light by magnetised media is rightly considered as involving gyrostatic properties in the ether and so far tends to confirm the hypothesis that the properties of the ether may be due to the rapid rotation of the parts of a fluid.

GEO. FRAS. FITZGERARD.

SOME RECENT WORK UPON MUSCLE AND NERVE.

THE appearance of an excellent English translation of the work of Prof. Biedermann affords an opportunity both for a brief notice of the book and for directing attention to some recent work in connection with the physiology of muscle and nerve.[1] The title of the book is somewhat misleading since the author comprises under the heading "Electro-physiology" not only the electromotive changes which under certain conditions present themselves in living tissues, but all the excitatory phenomena capable of being called forth by the action upon these of electrical currents.

Now the functional characteristics of such structures as muscle and nerve have been chiefly studied by acting upon these tissues through the medium of definite stimulating agencies and noting what changes are thus evoked. For this purpose the stimulating agency generally employed has been that of a brief electrical current and it thus follows that the study of the action of currents comprehends almost all the known phenomena of muscle and nerve activity. Prof. Biedermann's book, although entitled "electro-physiology," deals in reality with a far more extensive range of phenomena than that which the name suggests, and the scope of the work would be more correctly indicated by the phrase "phenomena of the excitable tissues". The treatise is the most comprehensive and most valuable contribution to the literature of the subject which has yet appeared, and since it deals with fundamental questions it acquires an importance in connection with the study of vital phenomena which cannot fail to be appreciated by all those who are interested in biological science.

It may be asked on what grounds the term "fundamental" is here used. Its employment will be justified if we briefly consider what are the essential characters of

[1] *Electro-physiology*, by W. Biedermann, translated by Frances A. Welby. London: Macmillan, 1898. 2 vols.

vital activity as displayed by those methods of inquiry now utilised by physiologists.

Living tissues are characterised by possessing peculiar properties, one of which is that of undergoing changes, the real causation of which is unknown to us. The changes are, however, readily recognised since they display themselves as physico-chemical effects of a definite and distinctive character. Each tissue shows a group of such effects which becomes more special as the tissue itself becomes differentiated in structure. The display of such definite changes is the sign to the physiologist that the tissue possesses vitality; the potentiality for such display may be termed its capability of functional activity, or, in short, "functional capacity".

This functional capacity is swayed by such conditions as the chemical nature of the environment, etc., it is thus not a constant quantity but one which varies, now increasing, now diminishing.

Its complete abolition beyond all power of recovery constitutes death, and thus the essence of the mysterious and unknown quantity termed life, is the possession by the tissue of this capacity for undergoing change of a definite character. It is, therefore, the possibility of the appearance of a new set of physico-chemical phenomena in such tissues as muscle and nerve which constitutes the fundamental characteristic of the living as distinct from the dead state. In these tissues the condition of activity can be evoked by producing physico-chemical changes in their substance. The evoking change acts in such cases, not as the causative factor of the subsequent active phenomena, but as an agent which releases, and thus initiates, a whole series of more subtle unknown chemical disturbances, the gross result of which we recognise as distinctive. Its action is analogous to that of the electrical current which fires a submarine mine and thus initiates an explosion. The releasing or initiating agency, in the case of the tissue, is termed the exciting cause or the stimulus, whilst the subsequent effects evoked by this are defined as those of the "state of excitation". Finally, the possession by any tissue of susceptibility to be brought into the state of excitation

on receipt of a stimulus is termed its "excitability," and, in proportion as this is more easy of achievement, so the tissue excitability is higher.

Muscular and nervous structures are those which show in the most marked degree excitability, and they are further characterised by the circumstance that the state of activity when evoked, is accompanied by phenomena which are readily recognised, such as movement and electrical changes. In plants the leaves of *Dionæa muscipulata* are similarly endowed with high excitability and an easily recognised state of activity. It is for this reason that the term "excitable" has been more or less used as a qualification for these tissues, but it is evident that the phrase "excitable tissues" must on philosophical grounds have a far wider scope, and may be taken to include all living structures.

All possess a functional capacity for change, and in all this change must be initiated by some physico-chemical event, which is therefore the releasing agency or stimulus. Even when the resultant effect is one of such slow development as the division of a cell, the manufacture and discharge from the cell of new substances and all the varied phenomena which constitute growth, the functional activity thus gradually displayed must be regarded as due to states of excitation evoked in excitable structures by appropriate although at present little known stimuli.

The capacity for passing into new physico-chemical moods and the property of being forced to perform this passage in response to definite stimuli, are thus fundamental characters of living as distinct from dead matter. Those tissues which show the phenomena best, such as muscle and nerve, enable us to grasp more completely than any others upon what conditions the possession of these fundamental characters depends. This is the real importance of the study of the excitatory phenomena of muscle and nerve, since we learn not merely their own individual traits, but obtain results which serve as sign-posts, guiding us along well beaten tracks towards the investigation of widely removed living structures.

Muscle and nerve possess in a marked degree other

fundamental vital characteristics. An excitable tissue passes into a new active state on receipt of a stimulus; the activity thus evoked may persist for a considerable time or may rapidly pass away, but in either case it is clear that a complete return to the resting inactive condition may accompany the subsidence of the state of activity. Such a restoration of the tissue, the remaking of the particular molecular combination which existed before the upset brought about by the stimulus, is a striking feature of the activity of muscle and particularly of nerve, hence these structures enable us to examine the conditions which influence this phase of the living cycle more completely than any others. The process is of fundamental importance, since it is the antithesis of that involved in the state of excitation, and both processes are present in every living tissue. The stimulus acts upon one of these, and it develops such preponderance that it masks the opposite one. It is the peculiar merit of Prof. Biedermann's book that this fundamental conception of living tissues so strongly urged by his master, Hering, is kept before the reader.[1] In such a tissue as muscle it is possible to ascertain many essential characters of the state of restoration, and to determine further how far the disappearance of the state of activity is a necessary prelude for the reinstallation of the resting functional capacity. Will the tissue respond to a second stimulus whilst the excitatory state evoked by the first is present? It is well known that striated muscle will respond in this way, so that even when a contraction due to one stimulus is present it will contract again. Hence in this tissue a portion only of the material whose change transforms the resting into the contracted muscle is affected by the exciting agent; a second stimulus can initiate a further transformation in another portion, and so on with a third and a fourth stimulus until the total mechanical effect reaches four times that due to the first response.

On the other hand this trait is by no means universally present, and even an allied structure like cardiac muscle

[1] The short account of Hering's theory of the functions of living matter, published in 1888, has been translated into English by Miss Welby, and appeared in *Brain*, vol. lxxvii., p. 232 (1897).

does not exhibit it. Here the explosive disturbance of the active state is accompanied by diminished susceptibility to respond to a stimulus, in other words, diminished excitability. The study of the precise conditions which affect the restoration of excitability and of functional capacity might be illustrated by many instances drawn from the physiology of muscle and nerve. It will be sufficient in an article of this character to indicate that the whole subject is treated in the most suggestive manner by Prof. Biedermann, and should afford valuable help to any who desire to ascertain how far modern physiology has succeeded in the investigation of such a fundamental vital attribute as the property of returning from the active to the resting state.

One other point of general interest is brought into prominence by the study of muscle and nerve now before us, namely, "functional capacity".

From the above remarks it will be gathered that "functional capacity" implies the capability of the tissue to undergo a change resulting in definite new effects those of activity, whilst "excitability" implies the susceptibility of the tissue to enter upon this change on receipt of a stimulus. At first sight the two phrases seem to be identical, but a little consideration will show that they are not, although it must be admitted that the significance of their separation has been only grasped during the last decade, mainly through the work of Hering and of Biedermann. The measure of functional capacity is the comparative amount of active display which the tissue is capable of showing, the extent and force of its excitatory explosion; the measure of excitability is the comparative ease with which it may be forced to enter upon its functional active state. Nerve is the most excitable of all tissue, and thus affords the best instances of the distinction just referred to. It may be rendered less excitable, but of increased functional capacity, by the passage of a weak voltaic current, this change occurring at the point of entry, or anode, during the current flow. On the other hand, it is more excitable but of diminished functional capacity at the point of exit, or cathode, of this current. Many other instances might be

cited of conditions which change excitability in one direction and functional capacity in the other; and since there are also instances in which the two both vary the same way, it is clear that the molecular foundations of excitability and functional capacity are not so firmly linked together that a change in the one must produce a corresponding change in the other.

We may picture to ourselves the living metabolism in any one region of a tissue, such as nerve, as consisting on the one hand of the tightening, and on the other of the loosening of complex molecular bonds. An apt illustration is afforded by the stability of a house built of cards, and having such a roof, that it is in itself an unstable structure. A slight shake of the table (the stimulus) can secure the downfall of such a house, and this downfall we may liken to the state of excitation.

Its degree of instability we may term its excitability; the more this is increasd, the more readily is the fall evoked. On the other hand the magnitude of the fall depends upon the number of cards which constitute the house, and as these are more numerous the capacity of the house to produce a large downfall is obviously increased.

Functional capacity is measured by the magnitude of the state of excitation, hence in the illustration functional capacity will be increased in direct proportion to the number of cards constituting the house and capable of being overthrown in its fall.

Now it is possible to make the house more stable by buttressing its sides with cards; it is now less readily upset (less excitable); on the other hand, if it should be upset the number of cards involved in its fall is increased (increased functional capacity). But it is also possible to render it more stable by removing those top-heavy cards which give to the roof its inordinate size and weight. Under these circumstances it is more stable (less excitable), but there are fewer cards to fall when it is upset (diminished functional capacity). The illustration will not bear being pushed, unless we introduce a human agency for the process of restoration, the rebuilding of the house

after its downfall, but it serves to illustrate the distinction between the capacity of a tissue for the active state and the readiness with which it enters upon that state. Although these two aspects, functional capacity and excitability, have been only conceived as distinct through the study of the phenomena of muscle and nerve, it is becoming obvious to all those who have worked upon the subject that the conception of their distinction is probably applicable to all living tissues, and thus we are presented with a striking instance of the use of the study of muscle and nerve in enlarging our views upon vital phenomena as a whole.

Prof. Biedermann treats in his book of other excitable structures possessing definite and easily recognisable excitatory states besides muscle and nerve; several chapters are devoted to the electromotive changes, in plants, in epithelial cells, in the retina and in electrical organs.

It would be undesirable to review in any detail the large amount of data which he has compressed into the pages which deal with these subjects; the subject-matter is somewhat complicated and special, but is admirably given, the sole fault which the reader is likely to find being *l'embarras de richesses* owing to the amount of data brought forward. Up to the year of its publication in Germany (1896) the work may be considered as a comprehensive account of the present position of our knowledge. In physiology, as in every growing science, two years implies a considerable extension of previously existing experimental data and the introduction of entirely new points of view to explain the results of recent inquiry. This has been the case with the physiology of the excitable tissues. It would be impossible in the present article to indicate the many different lines along which advance has taken place during the last year or two. The present writer has therefore selected two instances which his personal knowledge of the subject-matter has led him to regard with special interest, the one being taken from the physiology of muscle and the other from that of nerve.

The predominant feature of the state of excitation in muscle is undoubtedly the familiar mechanical change which

constitutes its contraction. It is well known that the phenomenon may be studied in the excised muscle of a recently killed cold-blooded animal such as the frog, for many hours after the removal of the muscle from the body; a rapid shortening or twitch occurs in such excised muscle when a single stimulus, preferably an induced current, is applied either to the muscle or the nerve supplying it. The study of the muscular response upon its mechanical side received a notable advance fifty years ago by the application of the graphic method devised by Helmholtz. This involves the attachment of one end of the excised muscle to the short arm of a small lever; since the other end of the muscle is immoveably fixed by a suitable holder, the shortening present during the twitch must move the lever and a longer arm of this can by appropriate arrangements be made to record its displacement upon a blackened surface moving at a known velocity. The record thus obtained is known to all physiological students as the muscle curve; since the rise of the lever with its subsequent fall is the agency which has actually written the curve, the curve itself indicates the successive positions which the lever has assumed at different periods of time.

The influence of various conditions upon muscular activity have been studied by obtaining such curves and noting what alterations are now present in the records. In this way the intensity of the stimulus, the temperature of the muscle, the alterations due to increasing mechanical load, the effects of previous muscular activity, of chemical substances and of many other agencies have been ascertained. In view of all this work it is a little singular that a point of prime importance involving the meaning of the record itself should have only come to the front recently. The muscle curve is the history of the movement of the lever to which the muscle is attached, and obviously this derives its value on the supposition that we may deduce from the movement of the lever, the mechanical change which occurs in the muscle. Does a light lever of the type described faithfully follow the muscular shortening? Is it a reliable historian or has it

a personal bias which garbles the account it gives of the event? As in historical so in these physiological inquiries, suspicion is cast upon the veracity of a writer by the fact that another account of the same event written by a different hand differs from the first in some important particular. Such a second record is obtained when the muscle is attached to a lever of essentially different construction. In that just described the lever always pulled with its small weight upon the muscle: the condition may be thus described as "isotonic" and the curve obtained by it as an "isotonic muscle curve".

But it is a familiar experience that muscles during contraction not only shorten in length but become tense. This stiffening is as much a mood of the mechanical response of muscle as is the shortening and may be communicated to a lever by a very simple device. The muscle is made to pull against a spring, preferably a steel wire fixed at one end and capable of torsion at the other. The torsion of the spring is always counteracting the mechanical tension of the muscle, if the latter increases the former must do so too. The slight movement of the steel wire, if recorded, will indicate any alteration in the amount of the torsion and as it may be easily arranged to move a fine lever, a magnified record of the change can be obtained upon a travelling blackened surface. The shortening of the muscle when it twitches under these conditions is now so little as to be insignificant; its length is kept approximately unaltered by the steel wire and it is thus said to be under isometric conditions, whilst the curve which is inscribed by the lever is termed the isometric muscle curve. It is, or rather it professes to be, the history of the development and subsidence of the muscular tension, and we have thus a second independent account of the mechanical change in muscle evoked by a single stimulus.

When the isometric and isotonic curves are compared it is seen that the two accounts differ in one essential particular, for the time relations of the curves are not identical; the isometric curve reaches its maximum from $\frac{1}{100}$ to $\frac{8}{100}$ of a second before the isotonic. The existence

of this discrepancy has been known for some time but has acquired a new interest from the animated controversy which is still going on between Schenk and Kaiser with reference to its meaning. There are at least two possible interpretations of the discord in the results. The first is that the muscular events recorded are not the same; both histories may be correct, but the mechanical condition of tension present when the isometric record is obtained, may be a disturbing factor and thus alter the muscular activity. This view is held by Schenk, who offers a number of experimental results suggesting that increase in the tension of a muscle so changes it that both the development and the subsidence of the state of activity are hurried up; the result must be that the culminating effort due to active contractile stress occurs sooner than it would otherwise do, since it is both accelerated in onset and cut short or inhibited as regards duration. In other words, Schenk regards a mechanical pull as capable of stimulating the functional capacity of the tissue both for passing into the active and for returning to the passive or resting state. This view involves issues of a comprehensive kind; one of which is the assumption of two separate excitatory processes, one that of activity the other that of subsidence, whose presence annuls or inhibits the former. It would be unprofitable to review at length in the present article the arguments for and against the acceptance of such an enlargement of our conception of excitatory phenomena. The absence of such a review may be further excused on the ground that Kaiser's interpretation of the discrepancy is of an entirely different nature. He regards the contractile stress in the muscle as the same, however, recorded; hence, as the muscular event is in his opinion unaltered, the discrepancy must be due to what may be termed the personal bias of one or both of the historians. Does the isotonic curve faithfully indicate the development and subsidence of the contractile stress evoked in muscle by a single stimulus? To ascertain this he has carried out a number of extremely ingenious experiments, the most convincing of which consist in the production of so-called "arrest" curves. These are

obtained by the following simple device. The upward movement of the isotonic lever is stopped by a suitable mechanism so arranged that the stop can occur at any desired interval after the record has begun. If this arrest occurs before the contractile stress of the muscle has ceased the lever will be held up against the stop; if on the other hand it occurs at the moment when the contractile stress ceases, the lever must fall. Now if the stop is arranged so that the lever falls immediately after its upward movement has been arrested, it is found that this fall begins at a point which is situated on the isotonic curve between $\frac{1}{100}$ and $\frac{8}{100}$ of a second before this curve has reached its maximum. Hence contractile stress has ceased although the isotonic lever continues to rise.

A further modification of the method is that of keeping the lever arrested and suddenly releasing it; here the same thing holds good, for if released before the contractile stress is over it will rise, and in this way the duration of the contractile stress may be determined.

The isotonic record is thus, according to Kaiser, the account of an untrustworthy historian, for it records other things besides the contractile stress. These other things are partly the movement of the lever due to its own momentum and partly that due to the passive elastic swing of the muscle itself. The twofold view of the muscle response advanced by Schenk is thus, according to Kaiser, unsupported by data derived from the muscle curves, whatever support it may receive from other sources. The response is the sudden assumption by the muscle of a new condition of elastic equilibrium and the subsidence of this is not a second response to excitation but is dependent upon the new condition coming to an end.[1]

Those who are acquainted with the methods employed in physiological investigation are not likely to underestimate the importance of the issues here raised, but even those

[1] The experimental data, together with the theoretical interpretations advanced by the writers concerned, may be found in Schenk's papers, *Archiv f. d. ges. Physiol.*, vols. 50, 53, 55, 61, 63 and 65, and in Kaiser's paper, *Zeitschr. f. Biol.*, vol. 33, etc.

whose work lies in biological or other fields of natural science must realise that since our knowledge of excitable tissues is largely founded upon the study of muscle, a controversy which involves the credit or discredit of the chief method employed for its elucidation, is by no means the least interesting episode in recent physiological science.

As regards nerve physiology the work of chief interest to the present writer is that which involves the study of the electromotive effects which accompany the presence in this tissue of the state of excitation. There are no known mechanical, chemical or thermal indications to show that nervous tissue has been thrown into the state of activity. Such a state is inferred in motor nerves from the circumstance that the supplied muscle to which the nerve is distributed responds when this nerve is excited. The combined nerve muscle preparation may be likened to an underground fuse leading to a mine where the successful firing of the fuse is indicated by the explosion of the mine. But since the discovery by du Bois Reymond fifty years ago that the state of excitation in nerve was accompanied by a change in electrical state, it has been recognised that the study of this state is a means, and at present the only direct means, for ascertaining the vital characteristics of the nerve itself. A very large number of different methods have been employed for the purpose, but the majority have all involved the frequent excitation of the nerve by a series of stimuli. This necessity has been due to the circumstance that the electrical change which accompanies the molecular disturbance is, when evoked by a single stimulus, too feeble and too short-lived to affect the most sensitive galvanometer. A vast amount of information has however been obtained from the summed effects of repeated stimulation, the galvanometric indications being under these circumstances both definite and considerable. By means of an ingenious automatic key, the revolving rheotome, Bernstein, Hermann, Boruttau and others have obtained a history of the development and subsidence of the aggregate or total of this multiple effect, and from such data they have inferred the history of each single change. All this is set

forth in great detail in Prof. Biedermann's work, but two extensions of the inquiry by English physiologists are too recent to be included and may be referred to here. The first is that made by Waller.[1] It consisted in recording photographically the galvanometric deflection produced by the aggregate of all the changes when the nerve is stimulated for a short period by a rapid series of excitations. The experiment is repeated over and over again at regular intervals and the resulting deflection caused by each series of stimuli thus occurs again and again and these can be photographed one after another upon a slowly moving sensitive plate. The results are valuable inasmuch as they are records admitting of comparison. They demonstrate that nerve is practically incapable of fatigue and show the extent to which both its functional capacity and its excitability are modified by changes in its environment. The influence of anæsthetic vapours of carbonic acid and carbonic oxide gases, of saline and acid reagents, etc., have been studied in this way; and the method undoubtedly opens up the possibility of determining in a more precise manner than heretofore the important question as to the mode in which chemical and pharmacological substances affect the nervous system.

The second method[2] is that employed by the present writer in conjunction with G. J. Burch. This consists in a special adaptation of the plan of research used by Burdon Sanderson in studying the electromotive phenomena of muscle.

It will be sufficient here to mention that it is dependent upon the employment of a special instrument, the capillary electrometer. This is particularly sensitive to rapid electrical change, and indicates the presence of such changes by a movement in the surface or meniscus of a fine mercurial column. The movement can be recorded by project-

[1] Waller: "Observations upon Isolated Nerve".—*Phil. Trans.*, 1896. Croonian Lecture.

[2] Gotch and Burch: "The Electrical Response of Nerve to a Single Stimulus investigated with the Capillary Electrometer".—*Proc. Royal Society, London*, cxiii., p. 300, 1898.

ing the column by means of a microscope upon a travelling photographic plate. In nerve the difficulty lies in the circumstance that the movement produced by nerve electrical changes must under all conditions be extremely small in extent, and that in addition to this it is of very short duration. It is thus impossible to follow it with the eye even when the magnified image of the mercurial column is so enlarged by projection as to be 400 times the size of the object. If, however, the plate is travelling with sufficient velocity the moving shadow thrown by the enlarged image, although too transient to be perceptible to vision, is found to have occurred when the plate is developed. In this way records have been obtained of the electrical disturbance evolved in nerve by each single stimulus, and convincing proof is afforded that this single electrical response, starting from the seat of stimulation, is successively assumed by each more distant portion of a continuous nerve tract. The method has the distinction of being the only one by which up to the present the single change has been recorded. A large number of experiments have been made with nerves under different conditions, and the modifications in the response consequent upon these have been recorded. We have here the start of an inquiry which will, it is hoped, effect for nerve what the graphic record has done for muscle, since each record is a graphic account of the nerve change as given by such an historian as the electrometer. Is the electrometer a reliable historian or has it a large personal bias? This question admits of much discussion, and has been taken up adversely by several of the leading German physiologists, particularly Hermann.

Without entering into the somewhat technical controversy, this much may be stated here. Each electrometer has its own rate of movement, its own personal equation; every record has therefore to be interpreted afresh after making due allowance for this personal bias of the instrument. Fortunately the amount and character of the bias remains approximately constant for any one instrument, so that if it can be determined the allowance is easily made for all records obtained from the particular instrument whose

characteristics are thus known. It has further been shown by Burch that the allowance having been made by taking appropriate measurements, the true history of the electrical disturbance may be always deduced from the distorted account recorded in the curve of the electrometer displacement, since the degree and character of the distortion are constant. This has now been done in the case of the records obtained from nerve, and if correct the deductions thus obtained indicate for the first time the magnitude, duration and character of the excitatory electrical disturbance of nerve. The present writer has a firm belief that before long similar methods of investigation will be more extensively applied to the study of nerve by those who up to the present have chiefly utilised older methods; if this should take place he feels convinced that as fruitful a field of research lies before those who are studying nerve phenomena as lay before physiologists when Helmholtz introduced the graphic method in connection with the study of muscle.

FRANCIS GOTCH.

NOTES ON PARASITES.

II.

THE parasitic habit of life is usually associated with certain structural peculiarities which present themselves in a greater or less degree in all the Entozoa. Among such peculiarities the most striking are (1) the presence of hooks and suckers or other objects of adhesion; (2) the shape of the body, adapted for insinuating itself into various spaces of the unfortunate host or for boring into his tissues, and in those parasites which live in such passages as the alimentary canal, being so moulded as to offer little resistance to the passage of food so that the intruders are not readily dislodged; (3) the tendency of the sense organs and nervous system to diminish; (4) the corresponding increase in complexity both in the structure of the reproductive organs and in the details of the development of their products; and finally (5) the tendency to do without a functional alimentary canal.

There are perhaps two other structures in the bodies of the larger Entozoa which show profound modifications possibly connected with their endo-parasitic mode of life. These are the epidermis and the body-cavity. In a former number of this journal,[1] I have described the condition of the skin in Cestodes and Trematodes as interpreted by Prof. Blockmann of Rostock. The condition of the epidermis in Nematodes and in the Acanthocephala is even more remarkable. Within the clearly defined cuticle which covers the bodies of these animals, is a layer of protoplasm more or less differentiated into minute fibrils and scattered through the substance of this layer are a certain number of nuclei. No cell limits are to be seen although they exist in the early stages of the development of the embryo.

This peculiar tissue is in the Nematodes heaped up into four ridges which run down the body, one dorsal, one

[1] SCIENCE PROGRESS, new series, vol. i., p. 78.

ventral and one on each side. These ridges divide the circular outline of a section through the body of a Round Worm into equal quadrants. Each ridge pushes between the muscle-cells which line the inner surface of the rest of the epidermal tissue and freely projects into the body cavity (Fig. II. *b*). The dorsal and ventral ridges surround the longitudinal nerves, the lateral ridges embrace the excretory canals.

There seems no reason to doubt that these ridges are epidermal in structure. On each side of them lie the mesoblastic musculo-epithelial cells, so characteristic of the Nematodes (Fig. II. *c*), which, together with the above-mentioned ridges, bound a spacious cavity—the so-called body-cavity—on the outside. This cavity is traversed by the alimentary canal, which for the greater part of its length consists of a single layer of cells, there being apparently, in these animals no mesoblastic perivisceral layer such as is ordinarily found in the Tripoblastica or animals with the three well developed embryonic layers.

Thus in the Nematoda the body-cavity has very peculiar and, in fact, unique relations. On the outer side it is bounded for the most part by mesoblast, but at the four axes by epiblast, and on the inner side it is limited by hypoblast. The relationship of this space to the embryonic layers is closely paralleled by that of the blood-containing spaces of such Cœlomata as the Vertebrata, which many years ago were shown, both on theoretical grounds[1] and by actual observation on the developing Lamprey,[2] to be primarily spaces between the epiblast and the hypoblast, or in other words, to be part of the segmentation cavity. This space in the higher forms subsequently becomes surrounded by mesoblast and forms the cavity of the blood vascular system.

Thus it is obvious that the space between the body-wall and the alimentary canal of Nematodes is not homologous with the cœlom of the Chætopoda, Mollusca, Arthropoda, Vertebrata, etc. The fact that it is not is further supported

[1] Bütschli, *Morphol. Jahrb.*, Bd. viii., 1883, p. 474.

[2] Shipley, *Quart. Jour. Micr. Sci.*, vol. xxvii., 1887, p. 325.

by the relations which it bears to the excretory system and to the reproductive organs. The former are not formed from its walls, and with the exception of certain aberrant species,[1] *Lecanocephalus* and *Dochmius*, the latter do not open into its lumen.

This space contains a corpusculated fluid, and probably it acts to some extent both as a blood-space and as a lymph-space. Within the last year a new light has been thrown on what goes on in the body-cavity of these lowly parasites by Prof. Nasonov[2] of Warsaw, who, utilising the methods of Kowalewsky, has demonstrated the existence in Nema-

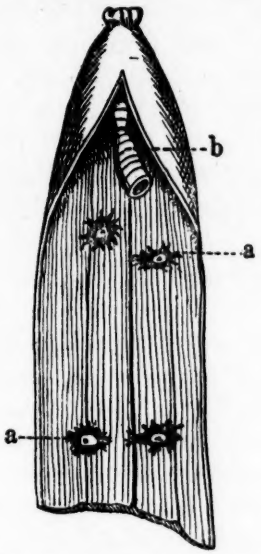

FIG. I.—Anterior extremity of the body of *Ascaris megalocephala*. x. 1·2. From Nasonov. The interior is exposed by a dorsal incision, two hours after an injection of Indian ink.

a. The star-like bodies in which the ink particles accumulate. The clear space is the nucleus of the giant cell.

b. The alimentary canal.

todes of certain gigantic cells which support others whose function it is to dispose of the foreign bodies which may, from some reason or other, make their way into the body-cavity of these creatures.

[1] Hamann, *Sb. Ab.*, Berlin, 1891, p. 57.

[2] *Zool. Anz.*, Bd. xx., 1897, p. 202, and *Arch. Parasit.* T. I., 1898, p. 170.

There has been the usual controversy as to who first saw these giant cells, but this much-debated question is comparatively unimportant, and no one, I think, denies that the Polish professor first demonstrated their function. By injecting carmine or Indian ink into the bodies of *Ascaris megalocephala* and *A. lumbricoides*, waiting some hours

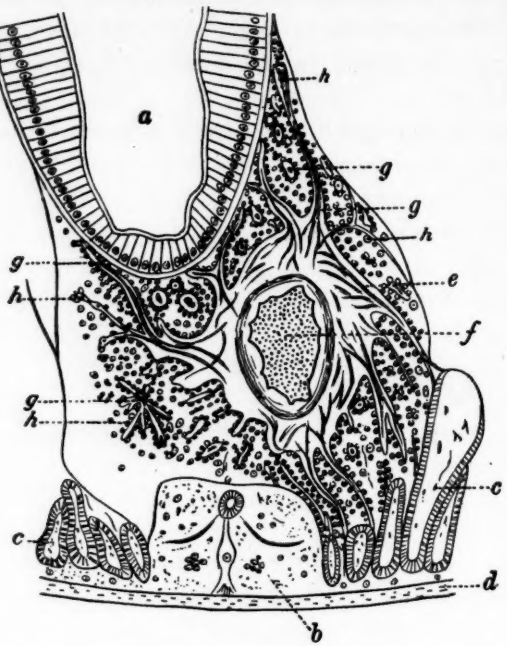

FIG. 2.—Transverse section through a star-shaped body, part of the alimentary canal and the skin of an *Ascaris megalocephala*. x. 85. From Nasonov.

a. The intestines.
b. The ridge of epidermis which surrounds the excretory vessel.
c. The muscle-cell.
d. The cuticle.
e. The giant cell.
f. The nucleus.
g. The fibrils of the giant cell.
h. The minute cellules which surrounds it.

and then investigating the parasites, he found that four enormous cells with branching processes, almost invisible under ordinary circumstances, had become so stained with the foreign material as to be visible even through the skin of the animal. (Fig. I. *a*.)

These four cells lie on the same level as the lateral excretory canals, two anterior and two posterior, but all lie in the anterior third of the animal. The cells are very large, in *A. megalocephala* attaining a length of 1 cm. and in *A. lumbricoides* of 3 mm. Each contains an enormous nucleus —so large as to be visible to the naked eye—and each breaks up peripherally into a meshwork of fibrils which attach themselves to the lateral lines, to the exterior of the alimentary canal and to the muscle-cells of the body wall. (Fig. II. *g*.)

The branching fibrils which run from the body of the cell to the neighbouring organs are coated with numerous spherical or pyriform bodies (Figs. II. *h*. and III. *b*.) in each of which Nasonow recognises a nucleus, in fact he regards them as minute cells attached not only to the fibrils but to the body of the giant cell. When carmine or Indian ink is

FIG. 3.—The end of two fibrils of the giant cell. From Nasonov.
a. The fibril.
b. The phagocytic cells.

injected into the body of the Nematode, the granules are taken up by these minute cells and accumulating around the fibrils and body of the giant cell render it visible even to the naked eye. In the same way they take up the bacilli of Anthrax or Tubercle bacilli and within their body these foreign germs are disintegrated and destroyed. Injection of appropriate reagents demonstrate that the reaction of these cells is an acid one. When kept at a temperature which does not materially differ from that of their host, and the giant cell is observed alive, it is seen that the minute cellules which surround it are capable of amœboid movements which no doubt assist in the ingestion of foreign particles.

We have, then, in the body-cavity of Nematodes at two different levels, a sieve consisting of two giant cells with processes spreading across the lumen of the space, and

each process clothed with minute cells eager to eat up any foreign matter which comes in its way, the whole forming a simple but apparently very efficient lymphatic gland. Whether these cells have a more intimate relation with the excretory canals on which they are situated, and whether the minute cellules which clothe them are not the corpuscles of the perivisceral fluid, temporarily come to rest, are at present speculations which it is to be hoped further investigation will clear up.

The last Numbers of the Studies from the Zoological Laboratory of Nebraska (Nos. 24 and 26) published under the direction of the eminent helminthologist, Henry B. Ward, contains an interesting summary of the number of parasites found in a given number of cats and dogs examined in the town of Lincoln, Nebr. Two of the parasites of the cat *Dipylidium caninum*—also found in the dog—and a Distomum, *Distomum felinum*, have been found in man. The latter is not uncommon in the peasants of Siberia, the former is, however, rare, and is as a rule confined to children of immature years. There is reason to believe that the second host of *D. caninum* is the *Trichodectes canis*, and children possibly become infected with it whilst playing with dogs.

Ward's investigations on the cat are not so extensive as those on the dog, and are less interesting because similar investigations have not been carried on elsewhere, consequently no data exist for a comparison between the number of parasites infesting the cats of the ancient cities of the Old World with those of a comparatively new town like Lincoln.

The following table compiled by Deffke, with the addition of the results of Sommer's investigations in Washington, D.C., and of Ward's at Lincoln, give some idea of the parasites of the dog in various parts of the world. The list does not include the Trematode *Hemistomum alatum*, recorded by Schoene in Saxony and elsewhere, nor does it include insect larvæ, Pentastomas or a species of Echinorhynchus found by Ward at Lincoln, in fact it is confined to the two orders, Cestoda and Nematoda.

Examiner and Locality.	Tænia serrata.	Tænia marginata.	Tænia cœnurus.	Tænia serialis.	Tænia echinococcus.	Dipylidium caninum.	Bothriocephalus latus.	Bothriocephalus fuscus.	Cysticercus cellulosæ.	Echinococcus polymorphus.	Mesocestoides lineatus.	Ascaris mystax.	Uncinaria trigonocephala.	Spiroptera sanguinolenta.	Eustrongylus gigas.	Trichocephalus depressiusculus.	No. of animals examined.	Percentage infected.
Krabbe, Copenhagen . .	—	17·3	2·16	—	1·08	47·03	—	—	—	—	—	20·54	1·62	—	—	—	—	65
Krabbe, Denmark . . .	0·2	14	1	—	0·40	4·8	0·2	—	—	—	—	24	2	—	—	—	500	72
Krabbe, Iceland . . .	—	75	18	—	28	57	—	5	—	—	21	2	—	—	—	—	100	100
Thomas, Victoria . . .	—	40	—	—	40	60	—	—	—	—	—	27	—	—	—	—	—	90
Thomas, South Australia .	—	27	—	—	40	60	—	—	—	—	—	27	—	—	—	—	—	80
Schoene, Leipzig or Saxony .	15	27	1	—	—	25	—	—	1	1	—	24	1	—	—	—	100	93
Deffke, Berlin, Germany .	—	57	0·5	—	1	40	0·5	—	—	—	—	18·5	4·5	2	1	—	200	62
Sommer, Washington, D. C. .	12	2	—	—	—	44	—	—	—	—	—	28	56	2	2	70	50	96
Ward, Lincoln, Neb. . .	4·5	5	—	5	—	65	—	—	—	—	—	20	10	—	—	—	20	75

With regard to the members of the two orders mentioned in the table, certain points in their geographical distribution are of interest. *Tænia marginata*, the largest Tænia which inhabits the dog, *Dipylidium caninum* and *Ascaris mystax* occur in all the widely distributed places mentioned. *T. serrata* is absent from Iceland, that home of dog-parasites, where 100 per cent. of the dogs are infested with some form or other of Entozoa. *T. cænurus*, whose larvel form infests the brains and more rarely the spinal marrow of sheep, is at present unknown in America, and is not mentioned in Thomas' lists from S. Australia and Victoria. The loss annually caused by the "Gid" or "Staggers," as the disease caused by its presence is called, has been estimated at 1,000,000 sheep in France and 35 per cent. of all the flocks in England, if the season be a bad one. Naturally it is commonest in sheep-dogs and comparatively rare in town-bred animals. *T. serialis* is also rare, in fact in some recent lists the name of its host is preceded by a query. It, however, undoubtedly occurs in the dog though only recorded on our list from Lincoln. *D. caninum*, as mentioned above, occurs both in the cat and the dog.

The really important parasite, from a merely human point of view, is the *Echinococcus polymorphus*, "the most insidious and dangerous parasite which inhabits the human system". In Iceland and in Australia it infests about 30 per cent. of the dogs examined. And when we are reminded that in the former island there are about twenty-eight dogs to every hundred inhabitants, and that during the long winter days men and beasts live together in the same huts without sanitary precautions, it is not surprising to learn that one in every forty-three individuals suffers from *echinococcosis*. Happily this form is absent from America, though Sommer has recorded 100 cases of the disease from the medical literature of the last fifty years. Probably the sufferers brought the parasite with them into the new country.

The result of the Nebraska research shows that on the whole there is a large percentage of harmless parasites in the dogs of that State and an excessive rarity—speaking

again from a purely human standpoint—of dangerous forms. These facts are to some extent explained by the recent settlement of the country and the uncontaminated condition of the fields. This state of affairs, coupled with the existence of large slaughter-houses where, as the meat-packers eloquently express it, "The only part of the hog which goes to waste is the squeal," is to a great extent responsible for the absence of those parasites which afflict the human species whether through his person or his pocket.

Of the Nematodes enumerated in the table, *Ascaris mystax* is rarely found in man, its accidental introduction into the system being due probably to the fondling of dogs or cats. *Uncinaria trigonocephala* produces a profound anæmia in dogs, especially in the sporting species. It occurs also in cats and gives rise to the disease known in Italy as *tifo dei gatti*, but does not attack man. The other species mentioned in the list are comparatively unimportant.

To the student of parasites one of the most important features of the present year is the appearance of the *Archives de Parasitologie*, under the able editorship of Prof. Raphael Blanchard, of the Faculty of Medicine, Paris. However much the multiplication of new journals is to be deplored, there was undoubtedly room for a periodical devoted exclusively to the study of parasites, whether they affect man or other animals, and judging from the first three numbers, the *Archives* are worthy to fill the vacant place.

Two features about the journal are new. One is the appearance of Spanish in addition to the four languages, French, English, German and Italian, to which polyglot zoological publications have hitherto been restricted. There is much useful work on Helminthology and Bacteriology being done especially in the Spanish-speaking Republics of South America—the opportunities are great—which only finds expression in the Spanish tongue; the cost of learning enough of the language to follow a scientific treatise is small, so that on all grounds we applaud the courage of Prof. Blanchard in adding Spanish to the list of languages in which articles for the *Archives* may appear.

The second feature which seems to us even more commendable is the appearance of a series of articles dealing with the history of renowned Helminthologists. The editor himself contributed to the April number a sketch of the life and work of Prof. R. Leuckart, illustrated by a characteristic portrait and a facsimile letter, and in the current issue is an admirable account of Francesco Redi. This remarkable physician, poet, courtier, lexicographer and zoologist,[1] who was born at Arezzo in 1626 and was buried in the church of San-Francesco in the same Tuscan city in 1697, was one of the earliest and greatest investigators into the anatomy and habits of Entozoa. He investigated with that object not only the bodies of numerous Vertebrates but also those of Cephalopods and Crustacea, and was the first to describe the Liver-fluke, a fact recorded by the name Redia, given to the larval Trematode by Filippi who first discovered it. Altogether Dr. Guiart records some seventy-five species of Entozoa studied by Redi.

The articles of a more strictly scientific nature are too numerous to mention; besides the more lengthy memoirs their are numerous short notices and reviews, so that the whole forms a compendious survey of the advance made day by day in the study of Parasitology.

ARTHUR E. SHIPLEY.

[1] If we may trust the poet, Redi was among the small number of teetotalers who have sung the praises of wine.

"Even Redi when he chaunted
Bacchus in the Tuscan valleys,
Never drank the wine he vaunted
In his dithyrambic sallies."

—*Drinking Song.* H. W. LONGFELLOW.

FLORAS OF THE PAST.

WEALDEN.

BY far the best known of the ancient floras are those of Upper Carboniferous and Lower Permian age. The wealth of material afforded by the sandstones, shales and coal-seams of the Upper Carboniferous system, and more especially by the petrified plant fragments from the calcareous nodules of the Lancashire and Yorkshire coal-fields, and the siliceous nodules of French and German localities, have enabled palæobotanists to reproduce a fairly complete picture of the vegetation of the Coal period. The excellent state of preservation of many of the older fossil plants has compelled the attention of botanists whose chief concern is with the plants of to-day. In addition to the splendid results obtained from a detailed anatomical investigation into the structure of special types of Coal-Measure and Permian plants, there are other facts of considerable interest to be gained from a general revision of Palæozoic floras from a phytogeographical point of view. Interesting results have already been obtained in this field of work,[1] but a critical comparative study of the component elements of the various Palæozoic floras should lead to the discovery of valuable evidence bearing on the questions of plant distribution and the existence of botanical provinces towards the close of the Palæozoic epoch. It is the botany of the oldest and, on the other hand, of the most recent geological periods that has so far received the chief share of attention at the hands of botanists, while the floras of the Mesozoic epoch have not hitherto attracted much notice from others than specialists.

In the present article it is proposed to attempt a brief summary of the general features of the vegetation of the Wealden period, special reference being made to facts which may prove of interest to botanical readers who are

[1] Zeiller. [*Vide* also SCIENCE PROGRESS (new series), vol. i., No. 2, p. 178, 1897.]

not familiar with the fossil botany of post-Carboniferous rocks. Although on the whole the plants from Mesozoic horizons occur in the form of casts and impressions, and the number of well-preserved petrifactions is extremely small in comparison with the material supplied by the older rocks, yet there are many facts of considerable botanical interest to be gleaned from an examination of Jurassic and Cretaceous floras. There is perhaps a tendency on the part of those whose main work is confined to recent plants, but who occasionally refer to palæobotanical literature with a view to giving a greater completeness to their conclusions, to confine themselves to the botanical evidence afforded by Palæozoic plants. For this and other reasons it is proposed to give a short *résume* of such data as we possess as to the composition of some of the floras of more recent geological age.

The geological system to which the name Wealden was first applied in 1828 has usually been placed by geologists at the base of the Cretaceous formation. It would seem, however, that some at least of the strata comprised under the term Wealden are more closely linked by the animal and plant fossils which they contain with the Jurassic rather than with the overlying Cretaceous system. In England the Wealden rocks are chiefly developed in the Weald district of Kent and Sussex; they occupy an oval-shaped area, bounded by the chalk escarpment, which extends from Folkestone Hill through the counties of Kent, Surrey, Hants and Sussex, to the sea at Beachy Head. Strata of the same age are also exposed on the south-west coast of the Isle of Wight, between Compton Bay and Atherfield Point, and to a less extent in the neighbourhood of Sandown, on the opposite coast. Since the early part of the century it has been recognised that the Wealden deposits are of a freshwater and fluviatile nature, and were evidently laid down in the delta of a large river which flowed through a low-lying country supporting a luxuriant vegetation. Fragmentary relics of the English Wealden flora were first described about seventy years ago by Mantell, Fitton, Brongniart and others, but it is only in recent years that

the rich collections which are now in the British Museum have been discovered; and considerable credit is due to Mr. Rufford of Hastings for having been the means of obtaining an unusually fine series of plants from the Wealden beds on the Sussex coast.

In the Island of Portland and on the neighbouring mainland coast near Swanage and Lulworth there is exposed a succession of strata, for the most part of freshwater origin, but containing a few intercalations of marine deposits. This series—long known as the Purbeck beds—is closely connected with the succeeding Wealden strata, both as regards fossil contents and conditions of deposition; it forms a part of the delta and lagoon deposits which were laid down in Southern England at the close of the Jurassic period.

The Wealden plants occur for the most part as fragmentary portions of twigs and leaves which were floated into their present position by the quiet waters of a river which rivalled in size some of the largest streams of to-day. In the Purbeck beds, and in the Wealden of Brook Point in the Isle of Wight, we have huge pieces of coniferous wood and cycadean stems which grew where their remains are now found as fossils, or were floated a short distance from the neighbouring forests.

From France but few Wealden plants have been recorded. In Northern Germany, on the other hand, there is an extensive development of freshwater Wealden beds, which has supplied Schenk [1] and other continental writers with rich material for palæobotanical study. Plants of the same age have been found also to the north of the Hartz Mountains and elsewhere. From Austria, Portugal,[2] Russia and the arctic regions [3] Wealden plants have also been obtained. The famous Belgian locality of Bernissart, which has furnished the Brussels Museum with more than twenty skeletons of *Iguanodon*, has afforded a few samples of Wealden vegetation.

There are a few other localities in Belgium—notably Bracquegnies — where plants have been found, but the

[1] Schenk (1) and (2). [2] Heer (1) and Saporta.
[3] Heer (2), Nathorst (2).

Bernissart beds are of special interest from the fact that by far the greater number of plant fragments belong to ferns, while cycads and conifers are barely represented. The Wealden deposits, which fill up a deep cañon cut through the Carboniferous rocks at Bernissart, appear to be the old sandy muds of a river which flowed through a marshy region inhabited by the ungainly Iguanodons and carpeted with a dense growth of ferns.[1] Some of the most important Wealden districts are in the North American continent, and the rich flora which they have afforded has recently received exhaustive treatment at the hands of Prof. Lester Ward. From Canadian rocks Sir William Dawson[2] has also recorded species of Wealden plants, but it is in the United States that the flora of this period is best represented. In 1889 Prof. Fontaine[3] published one of the United States Geological Survey monographs on the "Flora of the Potomac Series," and in this work there are described numerous well-known European species of Wealden plants. It has since been shown[4] that the Potomac formation—so named by McGee in 1885—includes rocks ranging in age from Jurassic to well up in the Cretaceous system; some of the lower plant-bearing strata are undoubtedly of the same geological age as the Wealden of Europe, and these have furnished many interesting additions to our list of Wealden species. Good evidence has recently been published of the existence of a Wealden vegetation in Japan,[5] and from Africa and New Zealand Wealden species have also been recorded.[6]

We will first pass in review some of the best-defined types of Wealden vegetation, and afterwards summarise the chief features of botanical interest, neglecting such plants as cannot be referred with certainty to a definite systematic position.

ALGÆ.—The majority of the so-called algæ from Wealden rocks are of no botanical importance, and at best merely afford

[1] Dupont. [2] Dawson. [3] Fontaine.
[4] Ward (3). [5] Yokoyama, Nathorst (1).
[6] For reference to the existence of Wealden species in these countries, *vide* Seward (1) and (2).

evidence of the existence of algal species very similar in the form of the thallus to certain recent seaweeds. We have on the other hand some good examples of the genus *Chara* which demonstrate the abundance of plants practically identical with our modern freshwater stoneworts.

BRYOPHYTA.—Under this head there are no Wealden species of special interest. Such fossils as may reasonably be referred to this class have a close resemblance to *Marchantia* as regards the vegetative form of the plant.

PTERIDOPHYTA.—The two divisions of the Pteridophyta most abundantly represented are the Ferns and Horsetails. We will briefly consider the latter first and then pass on to a few representatives of ferns.

1. *Equisetaceæ.* The numerous stem-casts of various species of *Equisetites* prove the abundance of slender Horsetails in the Wealden vegetation. None of the stems are much thicker than those of the larger species still living in Europe, and so far as we know the fossil forms agreed with their present-day descendants in the absence of secondary wood. The Equisetums of the Lower Oolite, and more especially those from Triassic rocks, had much thicker stems, and very probably grew in thickness in a manner comparable to the growth of the still older Calamites. The rhizomes of some of the Wealden Equisetums bore branches with tuberous internodes exactly like the oval tubers of *Equisetum arvense* L., *E. maximum* Lam. and other species.

2. *Filicinæ.* Unfortunately many of the Wealden ferns have as yet afforded little or no trustworthy evidence as to their systematic position, and in many cases we cannot do more than class the sterile fronds under provisional generic names, or at best hazard a guess as to the family to which they belong. There are however certain exceptions in which the family characters have been satisfactorily determined. The literature on Jurassic and Lower Cretaceous floras contains the names of several recent genera of ferns which are supposed to be represented by fossil species, but in not a few instances the choice of the name of a recent genus has been made without any real evidence to support it. Some of the most misleading determinations in

palæobotanical writings are those relating to fern fronds; a mere external resemblance in form between an imperfect specimen of a fossil frond and the leaf of a recent species has often proved too strong a temptation for even an experienced specialist. Many of the Mesozoic ferns referred to *Thyrsopteris*—a genus represented to-day by a solitary species confined to Juan Fernandez—*Aspidium*, *Hymenophyllum*, *Dicksonia* and other genera have no claim whatever to be accepted as well-established representatives of these generic types.

One of the commonest and most characteristic Wealden ferns is that named by Brongniart in 1828 *Sphenopteris Mantelli*; the tripinnate fronds of this plant are ovate-lanceolate in form, with narrow uni-nerved ultimate segments. The fertile pinnæ bear ovate and somewhat swollen segments, which present a striking agreement with those of some species of the recent genus *Onychium*. Although no individual sporangia have been preserved, the form of the fertile segments—in addition to the general similarity of habit—points to a close affinity with some of the tropical species of *Onychium*. On the ground of this resemblance, the generic name *Onychiopsis* has been substituted for that of *Sphenopteris*.

Casts of a Tree-fern stem usually referred to the genus *Protopteris*, but spoken of by some writers as *Dicksonia*, are not uncommon in rocks of Lower Cretaceous age; the stem is covered with crowded spirally disposed petiole-bases, in each of which the form of a horseshoe-shaped leaf-trace is clearly shown, and in an English example the vascular tissues of the stem have been partially petrified. In form and structure this genus presents a striking agreement with the recent Tree-fern *Dicksonia antarctica* Lab., and it is highly probable that this species is closely related to the Wealden plant. Some fronds of Wealden age have also been referred to *Dicksonia*, and these lend a certain amount of support to the comparison which has been made of the *Protopteris* stems with those of the recent genus.

A Wealden fern originally described by Dunker[1] from

[1] Dunker, p. 5, pl. ii., fig. 2.

North Germany as *Pecopteris Althausii*, and afterwards renamed by Schenk[1] *Matonidium Göpperti*, is closely allied to the living Malayan genus *Matonia*. Specimens of *Matonidium Göpperti* have been found in Wealden strata in Germany, Portugal, England and elsewhere; in the flabellate habit of the frond, and in the form of the sori, these fossils exhibit a striking likeness to *Matonia pectinata* Brown. The two living species of *Matonia*, *M. pectinata*, first figured by Wallich, and diagnosed by Robert Brown in 1830,[2] and *M. sarmentosa*,[3] described by Baker in 1888, are confined to Borneo and the Malay Peninsula; the genus has long been recognised as a type apart among present-day ferns, and some authors have placed it in a tribe by itself—the Matonineæ. Among Mesozoic ferns we have the Wealden species *Matonidium Göpperti* (Ett.), *M. Wiesneri* Krasser, recently described[4] from a somewhat higher horizon, and other species of the same genus; with *Laccopteris*, a Rhætic genus, and *Microdictyon Dunkeri*, another Wealden fern, which most probably belong to the same tribe as the recent *Matonia*.

An exceedingly interesting fern has recently been found by Dr. Bommer, of Brussels, in some sands of Wealden age near Bracquegnies; the plants from this locality have not yet been described, and I am indebted to Dr. Bommer for showing me the rich material on which he is preparing a memoir. The plant fragments were found in a loose sandy matrix; they occur as dark-brown twigs or leaves, and suggest the dried and discoloured pieces of recent plants which have been covered up for some years in a bed of sand. The stems and leaf-stalks are not crushed, and occasionally pieces of pinnæ with thin black pinnules still intact may be picked out of the Wealden sands. Among the ferns, the most interesting specimens are those of a *Gleichenia*; the habit of the fronds, the form of the pinnæ and pinnules, and the shape of the vascular strands, demonstrate beyond a doubt the generic affinities of the fossil.

[1] Schenk (1) p. 219, pls. xxvii., xxviii. and xxx.; (2) p. 160, pl. **xxvii.**

[2] Wallich. [3] Baker (*vide* also *Linn. Journ.*, vol. xxiv., p. 256).

[4] Krasser, p. 119, pls. xi., xii. and xvii.

Among Wealden ferns, which may be referred to as probable representatives of definite families or genera, the following may be mentioned :—

Ruffordia Göpperti (Dunk.)[1] (? Schizaceæ), species of *Acrostichopteris*[2] (*cf. Acrostichum*), also species referred to *Adiantum*,[3] *Aspidium*[2] and other genera.

GYMNOSPERMÆ.—1. *Cycadales.* The abundance of pinnate fronds of different species of "Cycads" is a characteristic feature of both Wealden and Jurassic rocks. In endeavouring to determine fossil cycadean leaves, we have to bear in mind the fact that it is practically impossible in many cases to be certain whether the fronds were borne by the stems of true Cycads or by stems of the genus *Bennettites*, which belongs to another division of the Cycadales. The Bennettiteæ represent an extinct group of plants which flourished during the Jurassic and Lower Cretaceous epochs ; in certain respects they agree very closely with the recent Cycadeæ, which are represented by *Cycas, Zamia, Dioon, Encephalartos*, and a few other genera practically confined to tropical regions. The stems of Cycads—or "Sago Palms," as they are sometimes popularly called—and of the Bennettiteæ resemble one another in general appearance, but the nature of the reproductive organs in the latter family precludes their inclusion among the true Cycads. In the Cycads the male and female flowers are borne at the apex of the trunk, and with the exception of the female flowers of the genus *Cycas*, they have the form of cones consisting of crowded sporophylls ; in the Bennettiteæ, on the other hand, there are special branches given off at right angles to the main stem, which terminate in an inflorescence of a more complex and highly differentiated type than the flowers of the Cycads. The existence of these fertile lateral shoots forms a ready means of distinguishing a Bennettitean from a Cycadean stem ; the stem of *Bennettites* is enclosed in an "armour" of persistent leaf-bases as in the ordinary Cycad, but there are crowded series of smaller scale-leaves here and there in the axil of a petiole, which mark the position

[1] Seward (1), p. 76 ; pls. iv.-vi. [2] Fontaine, pls. clxxi. and clxxii.
[3] Saporta, pls. x., xviii., xxix., etc.

of lateral shoots bearing linear lanceolate scale-leaves. These shoots terminated, at least in some species, in an inflorescence of the type to which Carruthers gave the name *Williamsonia*. Prof. Lester Ward[1] has suggested the inclusion of all fossil cycadean stems in the sub-family Cycadeoideæ of Robert Brown. Seeing how distinct a type the genus *Bennettites* represents, it is, I believe, much better to retain the family Bennettiteæ, and to use the generic name *Cycadeoidea* of Buckland for certain fossil stems which cannot be certainly referred to *Bennettites*.[2] In strata of Wealden and Lower Greensand age stems of the *Bennettites* type are fairly common; by far the most numerous are the large silicified stems from the Black Hills of Dakota, from Maryland and other districts of North America.[3] The English species *Bennettites Gibsoni* Carr, from Lower Greensand rocks, is the most perfectly preserved specimen so far described; other English species occur in the Purbeck beds of Portland and elsewhere. From Italy, too, several examples have been described by Counts Capellini and Solms-Laubach.

There are certain species of cycadean stems from Wealden and Purbeck beds which agree with the recent Cycads in having no lateral fertile shoots, and which may probably have borne terminal flowers; traces also of cycadean flowers have been recorded. It would seem, then, that both true Cycads and the extinct Bennettiteæ were in existence side by side in the Wealden period. Unfortunately the cycadean fronds, such as species of *Otozamites*, *Dioonites*, *Zamites*, etc., which are common Wealden fossils, are found in the rocks apart from their stems, so that we must speak of them as fronds of "cycadean" plants in the wide sense, remembering that probably many of them were borne by stems of the Bennettiteæ.

2. *Coniferæ*. Among the numerous examples of coniferous twigs, wood and leaves there are several species which may be safely referred to definite genera of existing

[1] Ward (5), p. 5. [2] Seward (4).

[3] A splendid example of an American cycadean stem has recently been added to the Fossil Plant Gallery of the British Museum.

conifers. The well-known "Pine-raft" at Brook Point in the Isle of Wight and the Purbeck beds of Portland have furnished numerous specimens of coniferous wood, with the structural details more or less perfectly preserved. Prof. Lester Ward has recently given some account of the Wealden and Purbeck woods from English localities, and states that all the fossil wood is of the Araucarian type.[1] This must refer, however, to such wood as Prof. Ward has himself examined; it is certainly not a statement which can be accepted as covering all the known woods from the Wealden-Purbeck strata. It is a matter of regret that no one has so far made a careful examination of the silicified woods from the Purbeck beds of Portland, nor to any great extent of those from the Isle of Wight; Prof. Ward justly remarks: "It is surprising that no one in England has thought to describe or name these fossil woods, and I would not have ventured to do this on the imperfect material in my possession, if it had not seemed to be the only way in which they could be brought into their systematic position as an integral part of the fossil flora of the Wealden".[2] Two specimens of wood, one from Portland and the other from the Isle of Wight, are described by Dr. Knowlton in Prof. Ward's memoir; both are referred to as *Araucarioxylon*, but the preservation is far from satisfactory, as admitted by Dr. Knowlton, and demonstrated by his figures.[3] Visitors to Portland are probably familiar with a silicified stem, about 20 feet long, fixed to the front of a house in Fortune's Well Street; this stem was briefly referred to by Fitton in 1834, and the same stem has now been named by Lester Ward *Araucarioxylon antediluvianum*,[4] the specific name being chosen from that of the house against which the stem is placed. It is to be regretted that the name *Araucarioxylon* has been adopted without the evidence of internal structure; no one, so far as I am aware, has ever seen sections of this particular stem. Prof. Ward has done good service in reminding us of a strangely neglected duty, but the determination of the Purbeck and Wealden woods must be the

[1] Ward (4), p. 491.
[2] *Ibid.* (4), p. 496.
[3] *Ibid.*, pp. 495, 496, pl. cii.
[4] *Ibid.*, p. 491.

result of careful and systematic investigation of well-preserved specimens, or the names assigned will possess no scientific value. An exceedingly careful piece of work of this kind has just been completed by Mr. C. A. Barber,[1] who has investigated the structure of some coniferous wood of Lower Greensand age from the Isle of Wight; he names the species *Cupressinoxylon vectense* Barb. Dr. Knowlton[2] has also described a species of the same genus from rocks of approximately Wealden age near Washington.

The genus *Pinites* is well represented not only by petrified wood possessing the anatomical characters[3] of the recent *Pinus*, but also by numerous leaves, twigs and cones. The genus *Araucaria* has also Wealden representatives in the form of wood described under the generic name *Araucarioxylon*, and in leaf-bearing twigs and cones. Some of the coniferous twigs described under the names *Pagiophyllum* and *Sphenolepidium* are, no doubt, fragments of Araucarian trees, and it has been suggested that certain examples of *Sphenolepidium* are near allies of the recent genus *Sequoia* now confined to California. The genus *Brachyphyllum*, another common Wealden conifer, bears a remarkably close resemblance in the formal and stiff habit of its branches with small adpressed scale-leaves to some species of the archaic-looking Tasmanian genus *Athrotaxis*. Specimens referred to *Thuytes* and other genera may be regarded as representatives of the recent Cupressineæ; and the genus *Nageiopsis*, especially characteristic of the American Potomac beds, and represented by one or two fragments from an English locality, may be a near relative of some of the recent species of *Podocarpus*. It must be remembered, however, that the leaves of the Australian *Araucaria Bidwillii* Hook. agree very closely with those of the fossil *Nageiopsis*, and this genus must be left for the present as one of doubtful systematic position.

From Germany and elsewhere, but not so far from any English Wealden locality, leaves have been described which are practically identical with those of *Ginkgo biloba* L., the maiden-hair tree, an aberrant and almost extinct member

[1] Barber. [2] Knowlton, p. 46, pls. ii. and iii. [3] Carruthers, Seward (3).

of the Coniferæ, which was formerly widely spread throughout the American and European continents in Mesozoic and Tertiary times.

Numerous other genera which might be compared with more or less probability with existing types, need not be considered; nor can we discuss the various examples of Wealden plants which possess certain features of interest but are of no special importance from our present point of view.

In summarising our knowledge of such Wealden species as may be referred with a considerable degree of certainty to existing families or genera, the following may be mentioned :—

CHAROPHYTA.—*Chara Knowltoni* Sew. *C. Jaccardi* Heer.

BRYOPHYTA.—*Marchantites Zeilleri* Sew.

PTERIDOPHYTA.—

1. EQUISETACEÆ.—*Equisetites Burchardti* Dunk. *E. Lyelli* Mant.
2. FILICINÆ.—
   (*a*). Polypodiaceæ. *Onychiopsis Mantelli* (Brongn.). *O. elongata* (Geyl.).
   (*b*). Matonineæ. *Matonidium Göpperti* (Ett.) ? *Microdictyon Dunkeri* (Schenk).
   (*c*). Cyatheaceæ. *Protopteris punctata* Sternb.
   (*d*). Gleicheniaceæ. *Gleichenia* sp.
   (*e*). ? Schizaceæ. *Ruffordia Göpperti* Sew.

CYCADALES.—

1. BENNETTITEÆ. *Bennettites Saxbyanus* (Brown). *B.* (*Williamsonia*) *Carruthersi* Sew. Also several American and other species.
2. ? CYCADACEÆ.—*Yatesia Morrisii* Carr. *Bucklandia anomala* (Stokes and Webb). *Fittonia Ruffordi* Sew. *Androstrobus Nathorsti* Sew. *Cycadeoidea gigantea* Sew. (This species of Purbeck age agrees with *Bennettites* is the possession of the characteristic fern-like ramenta on the petiole bases, but there is no evidence of any lateral shoots bearing flowers.)

The numerous species of cycadean fronds cannot be assigned with any certainty to one or other sub-division of the Cycadales.

CONIFERÆ.—*Pinites Ruffordi* Sew. *P. Solmsi* Sew. *P. Dunkeri* Carr., etc. *Araucarites* sp. *Araucarioxylon* sp. *Thuites* sp. *Brachyphyllum obesum* Heer. *B. spinosum* Sew. (*cf. Athrotaxis* sp.).

The most striking fact revealed by a general review of the Wealden flora of England, Germany, and most other regions is the absence of any genera which can reasonably be referred to that great class of flowering plants which constitutes so large a proportion of present-day vegetation. It is true that certain fossil angiospermous leaves have been described by Fontaine [1] and Lester Ward [2] from the lower members of the Potomac formation which contain plants of a distinct Wealden facies, and by the late Marquis of Saporta [3] from rocks on a corresponding horizon in Portugal. The published drawings of some of these so-called archetypal Angiosperms are highly suggestive of fern leaves with reticulate venation; and while admitting the possibility that some few fossil leaves from true Wealden beds may be those of dicotyledonous trees, I believe it would be too rash a statement to make that we have so far discovered undoubted Angiosperms in the Wealden flora.

In connection with this question of the first appearance of angiospermous leaves, I may mention that there are two fairly clearly preserved leaf-impressions, which appear to be those of Dicotyledons, in the British Museum collection of fossil plants from the Stonesfield slate of Oxfordshire. The plants from this lower horizon (Great Oolite) are now being revised with a view to a comparative treatment of the Stonesfield flora.

As regards the ferns of Wealden age, the absence of any species which afford evidence of Marattiaceous affinities is a point of some interest. In the Palæozoic vegetation the small tropical family of the Marattiaceæ appears to have been abundantly represented, but in the Mesozoic epoch, at least in the more recent formations, this division of the Filicineæ occupies a position much more in accordance with that which it holds to-day. A small fragment of a sterile pinna from Portugal has been referred by Saporta to the genus *Marattia*,[4] but it is difficult to understand on what grounds the name has been adopted. Another fact which is illustrated by the Wealden flora, and in a still more

[1] Fontaine. [2] Ward (3). [3] Saporta.

[4] *Ibid.*, p. 83, pl. xvi., fig. 14.

striking manner by Mesozoic floras of a slightly different age, is the wide distribution and abundance in the European vegetation of species of the *Gleichenia* type. Species of other genera similarly throw light upon the wider distribution and greater abundance of ferns now confined to the tropics.

The chief interest connected with the Wealden cycadean flora is the abundance of the Bennettiteæ, plants which flourished for only a short period during the Jurassic epoch and the beginning of the Cretaceous period. This is not the place to describe in detail the various morphological features of the genus *Bennettites*;[1] it is a type of plant which had no doubt a common ancestry with the true Cycads, and in the structure of its female flowers displayed a nearer approach to angiospermous characters than is the case in the reproductive organs of the Cycads. The Bennettiteæ probably represent a branch of the cycadean phylum, which cannot be traced to any direct offshoot among existing types.

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A. C. SEWARD.

APPENDIX.

NOTICES OF BOOKS.

An Introduction to Human Physiology. By Augustus D. Waller, M.D., F.R.S. Third Edition. 1896.

We congratulate Professor Waller on the appearance of a third edition of this work. An interval of barely five years extends between the first edition and the present. The book has been a pioneer in several ways, amongst others in the limitation of the scope of an English manual on physiology, written avowedly for the use of students of medicine, to physiology alone without the addition of extraneous histological description. As a complete text-book of moderate dimensions on human physiology we regard it as the best in the language. Nor do we know of any so good either in French or German.

Physiological problems are not easy to investigate with success, neither is the science one that lends itself to being "embraced with an easy span". At least as difficult is it to convey within the compass of 600 octavo pages a comprehensive survey of the physiology of man. The physics and chemistry of animals being a large subject, the medical curriculum with right-minded modesty demands only a part of that whole. That part, however, the part concerning man, is and certainly for long will be the larger fraction. "The proper study of mankind is man," and his physiology includes the brain as an organ of mind. To all this larger fraction—and in reality to much else besides—Professor Waller's book is excellent "guide, philosopher, and friend".

In a text-book of not immoderate dimensions there are obviously certain lines only on which a science can be traced. The historical method is scarcely admissible in a treatise of that size. Approved facts can be judicially selected from the whole mass available, and these catalogued will give a monument of evidence so far as they go. They are however not the study itself but only the subject matter of the study. Moreover, the inductive is only part of the method pursued by physiology. Leaning on the exacter and more mathematical studies of physics and chemistry it uses laws revealed by them—instance that of the conservation of energy—as instrument for analysis of the corporeal machines which form its subject. Besides facts therefore generalisations, wide and limited, must also be deposited in the text-book. The question is for every volume, how many and how far? In text-books it is too current not only to *catalogue* facts but also to *catalogue* generalisations. The small manual of physiology usually devotes a line to each doctrine, the name of an authority being thereto appended label-like. This is honesty, but it is not responsibility, and from the latter no mind teaching another mind may shrink. What wonder under such

lapse of duty if by the student, even though the label be remembered, that to which it belonged soon fade forgotten.

In the book before us it is pre-eminently the generalisations, the opinions, of his science which the writer sets himself to tell, and in no instance does he fail to unfold each in the manner of a thesis to be defended in the presence of impartial but of critical inquirers. Pursuing that course his facts come forward duly as items of evidence ordered in natural sequence for a logical mind. It is in direct proportion as this can be done with any study that it can claim to possess educational value. It is only when such a method is pursued that the student grasps the proportion of the unknown to the known. It is only in such a teacher that the student acquires that confidence which loyalty of acknowledgment of want of knowledge is one of the most powerful means to inspire. No one can lay down the present book without realising that its subject science, altogether apart from its technical applications to practical medicine, is replete with value as an educational means, and is expounded in such a manner as to fit it for that end. For this Prof. Waller should have the thanks of all, especially of English physiologists, for certainly no single volume of moderate compass in the language had realised this aim. Physiology, although it is a truism to say that it forms the basis of the art of healing, is too often thought of merely as an appanage of medicine. But physiology has a wider aim than that. It will "raise its voice, not only in the hospital and consulting room, but in the school and in the senate". Changes in what we call the body bring about changes in what we call the mind. History, as surely as she prophesies a fuller and more exact knowledge of that molecular dance, which is the material token of nervous action, prophesies to physiology a place of appeal and law-giving in questions not only of the body, but also of the mind. To this no stronger witness can be pointed than all the latter part of Prof. Waller's chapter xv. Though this book is written avowedly for the student of medicine, it is an admirable introduction to human physiology for any student bent upon that knowledge for its own sake only. Indeed the chief evidence that the author has addressed himself in particular to the medical student is the insertion in the volume of a certain amount of elementary physics at the expense of space that might have contained physiology. This is no fault of the author's. The teacher of physiology has early to recognise that he has usually to deal with students who know little or nothing of physics. The regulations of the great diploma-granting Conjoint Board in the metropolis requires no general course of instruction in physics as a part of its course of education for the physician and the surgeon. The teacher before beginning to lecture upon muscle, in treating of which he must perforce employ electricity, is obliged to explain the nature of the voltaic cell, of the induction coil, and of the general facts regarding resistance, and the detection and measurement of currents. Similarly, his microscopical analysis of muscle-structure has to be prefaced with a statement

of facts regarding polarised light and the construction of polarising apparatus. Were a course of instruction in general physics obligatory at the beginning of the education of all medical students, the case would be different. But the only person concerned with his education who does require of the diploma student a certain knowledge of physics is his physiological teacher. Hence a number of Prof. Waller's pages are occupied with statements belonging to elementary physics and with descriptions of ordinary simple physical instruments. These are admirably given; but probably no one realises more vividly and regretfully than their author the sacrifice they necessitate of rightful physiological matter, for it is he who is best acquainted with the keenness of competition of rival matters for every paragraph of a text-book like the one he gives us.

The tone of utterance of Prof. Waller's book is piquantly dogmatic. It is condensed not by abbreviation of construction so much as by epigram. Brevity is the soul of wit. In other words, compression of thought engenders force of thought. In physiological phrase, contrast emphasises words and ideas as it does colour-sensations. For a teacher to be successful dogmatism is unavoidable; he must be dogmatic. There are whole pages in this book that teach almost in epigram. This may be dangerous. Epigram is akin to paradox, and no paradox was ever either the whole truth or nothing but the truth. Nevertheless it is part of the superlative value of this book, for it attracts and interests and incites inquiry, in short captivates for an earnest science a new student lover. The book is indeed that rare thing—a serious scientific manual possessing literary style. Its fertility of expression has begotten phrases that have already become dear to the examinee. The student in *viva voce* replies, making one start, "The appetite for special centres has lost its edge"; or says blandly, "The hypnotised person is one in a state of suggestibility". He has often much of this Wallerian manner in him, and let us hope its matter is with him as abiding knowledge.

The new matter introduced into this edition of the book is chiefly contained in that portion which deals with nerve and retina, and the chapter on Animal Electricity. The results of the author's comparative researches on the influence of vapours, especially of anæsthetic vapours, on nerve, are succinctly related and illustrated by seven new original figures.

The book before us has yet another value for the student of medicine. It is the book latest placed in all his curriculum which possesses first-rate educational as well as technical value. It presents worthily the most philosophical, the least empirical, knowledge that his profession demands of him. The exercises of human anatomy, devoid of scientific quality, involve mnemonic gymnastics of a kind, but as intellectual training they are probably worse than useless. The apology for the time spent on human anatomy is that of the catalogue of minute facts composing it. Some are of importance to the applied

technique of healing. On the contrary, by the volume before us the whole scientific basis of medicine is introduced. How a student giving a fraction of his time for a year can be supposed to conscientiously master its contents is a matter that will strike any practical person who turns over the pages of the book. The ordinary student cannot possibly do so, and a change must be made for him. When it is, nor is it apparently long distant, we hope Prof. Waller's *Human Physiology* will even more generally come into use than at present. The book is largely read already we know by University students, but it is not sufficiently used or examined upon in the hospital medical schools because there diploma students are in the majority. The volume is capitally illustrated. The figures are for the most part original, and even of those borrowed not a few have received signal improvements for a teaching purpose, *e.g.*, Goldscheider's, fig. 262.

No flattery can be more sincere than that which takes the form of imitation. The influence which this text-book, since the appearance of its first edition several years ago, has exercised on English physiological manuals must, to its author, have been amusing if no more. The result has been most beneficial to our students. We congratulate him on having borne his pleasure in silence.

It is difficult to single out passages for special commendation. Did we attempt it, one taken would be the summary of hypnosis, only four pages long, and yet containing everything wanted. Occipito-retinal correspondence, and the masterly paragraph on the place of psychological terms in physiology, would be others. The whole chapter on animal heat is very excellent. Reference might with advantage be made to Dr. Haldane's gravimetric method of estimation of the respiratory exchange. Have the pages been re-indexed for this edition? We would also urge the addition of a centimetre scale to the measures given in the appendix. It is not easy to realise the difficulty which the English student has in visualising the to him still unfamiliar metric units.

We believe that a French translation from the present edition has been undertaken by Professor Herzen of Lausanne and will be published by MM. Masson, Paris.

In conclusion, we repeat that this *Introduction to Human Physiology* is, of all the manuals of moderate size which we know on the subject, the best. It is wholly admirable. We hope it will succeed more and more in displacing other and smaller text-books from the field, for its victory will be a reliable sign of educational progress in this country.

The Calculus for Engineers. By John Perry, M.E., D.Sc., F.R.S. Edward Arnold. Price, 7*s.* 6*d.*

This book cannot fail to prove of great use to a large class of readers. In his introductory remarks the author states that he writes

more particularly for readers who have had very little Mathematical training, but that he also has in view readers who already know a good deal about the Calculus, but are unable to apply their knowledge in practical Engineering problems: "A man learns to use the Calculus as he learns to use the chisel and file on actual concrete bits of work, and it is on this idea that I act in teaching the use of Calculus to Engineers".

The powerful tools of the Calculus are put into the hands of the reader, and he is shown to what use they may be turned in the solution of Engineering problems.

The first chapter of more than 150 pages is devoted to the study of x^n. The use of squared paper is explained, and a set of exercises on graphing are given: also the method of investigating whether any empirical law such as $y = \frac{ax}{bx + c}$, or $yx^n = \text{constant}$, connects two variables x, y, of which sets of simultaneous values have been experimentally determined. By means of numerical illustrations the idea of a limit is clearly shown, and the absolute accuracy of a differential coefficient as a rate-measurer brought home thoroughly to the mind of the reader. The arithmetical method of finding approximately the acceleration at different points of a moving body whose positions at close intervals have been observed, is illustrated in a table.

The integration of $\int x^m\,dx$ is immediately defined as the inverse of differentiation, and here perhaps it might have been well to have shown at length that $\int_a^b F'(x)\,dx = F(b) - F(a)$

Partial differentiation, maxima and minima, and tangents and normals to a curve are briefly explained, and then areas of closed curves, lengths of curves, volumes of surfaces and moments of inertia are dealt with, and a large number of illustrative problems on the bending o beams, the flow of liquids, magnetism, and thermodynamics, are discussed, nearly all of which require no further knowledge of the Calculus than the differentiation and integration of x^m.

Chapter ii. deals with the compound interest law and harmonic functions, that is with problems involving the functions e^x and $\sin ax$, a quantity whose rate of increase is proportional to itself being said to follow the compound interest law. Here again numerical illustrations of the value of the differential coefficients are recommended to the consideration of the reader, and many electrical and mechanical problems are discussed. Fourier's theorem is stated, and its practical application is explained. On the subject of vibrations a very instructive numerical example of a linear differential equation with constant coefficients is worked out at length.

Chapter iii. is called "Academic Exercises," and contains in brief some of the usual elementary portions of the ordinary treatises on Differential and Integral Calculus and Differential Equations. Elliptic

Integrals are just touched upon, also spherical harmonics, Bessel's function, hyberbolic functions and gamma functions. The chapter closes with a problem on the conduction of heat, and a tabulated list of integrals.

The book is printed in clear, good-sized type, on good paper, answers are in nearly all cases given to the exercises, and an index is provided.

To the teacher of the Calculus, no less than to the Engineer, this book will prove of great value as a rich storehouse of practical illustrative examples, by means of which he may impart to his students a real useful working knowledge of the subject.

Vorlesungen ueber Bakterien. Von Dr. Alfred Fischer, a.o. Professor der Botanik in Leipzig. Mit 29 Abbildungen. Jena: Verlag von Gustav Fischer, 1897.

All who have followed Prof. Fischer's work on Bacteria will open his new book on these organisms with anticipatory pleasure. Nor will they be disappointed. Since the publication of Dr. Bary's fascinating lectures, nothing has been written concerning Bacteria, which gives so clear and interesting a sketch of the present state of our knowledge in this department of Botany as does Dr. Fischer's new book. With the advance of knowledge, much of what we used to accept as fact has been found to require revision, and not only have many of the old puzzles been gradually solved, but many new paths of inquiry have been opened up. Winogradsky's magnificent researches are ably summarised, and the results, showing that some bacteria possess the power of assimilating the carbon dioxide from the atmosphere, others again that of obtaining their energy by oxidising sulphuretted hydrogen, first to water and sulphur and finally to sulphur dioxide, instead of relying on the oxidation of carbohydrates, are presented in a clear and readable form.

The bacteria concerned in the fixation of nitrogen and the relation of the process to the carbohydrates obtained from the leguminous plants, in which they engender the formation of tubercles, receives a clear though somewhat brief exposition.

Some of the other instances of symbiosis however are not so happily chosen. In a book of this kind, a discussion on the symbiotic relations of fungus and alga in lichens seems to be somewhat out of place, and the beautiful case of the gingerbeer plant, so thoroughly investigated by Marshall Ward, might with advantage have been substituted. As it is, this, perhaps the most striking example of symbiosis of its kind, finds no mention at the hands of our author. The later chapters, dealing with the relation of bacteria to disease are perhaps less interesting than many of the preceding ones, but within the compass of a short course of lectures, such as that of which the volume before us is made up, possibly this is not easily avoidable.

Dr. Fischer adds another to the steadily growing lists of proposed classifications, and he attaches considerable importance in delimiting his genera to the absence or the presence of cilia, and to the mode of arrangement of the latter when they exist.

As an important contribution to the literature of Bacteria, the book will form a necessary addition to the library of all who are interested in these organisms, while even the general reader will find a great deal which cannot but be of great interest to him.

Das Kleine Botanische Practicum für Aufänger. Dr. Ed. Strasburger, o. ö. Professor der Botanik an der Universität Bonn. Dritter umgearbeitete Auflage. Mit 121 Holzschnitten. Jena: Verlag von Gustav Fischer, 1897.

The smaller edition of Prof. Strasburger's *Practicum*, like the larger work which is so widely known, has passed through another edition, and we notice several improvements in the volume in its present form. The number of types is reduced, and all will probably agree with the author in recognising that less done thoroughly is better than more done superficially. As would have been expected, the new edition is thoroughly—especially as regards the latest work on nuclei—up to date, and is admirably arranged, not only to suit the learner but also to help the teacher.

Bau und leben unserer Waldbäume. Von Dr. M. Büsgen, Professor an der grossherzoglich sächs. Forstlehranstalt in Eisenach. Jena: Verlag von Gustav Fischer, 1897.

The object of the volume before us is to give a semi-popular account of the structure, physiology and general mode of life of our forest trees. Such a book is not a very easy one to write, and we can hardly say that Dr. Büsgen has quite succeeded in his task as a whole. Indeed, we must confess to finding his book a trifle dull. It contains, however, some useful summaries of views which have been advanced as explanations of certain problematical phenomena; thus the mode of the formation of annual rings is briefly but fairly discussed in five pages, and a tolerably good account is given of the contributions made by Dixon and Soly and by Askenasy towards the solution of the old-standing riddle as to the ascent of sap in tall trees.

Applied Mechanics, a treatise for the use of students who have time to work experimental, numerical, and graphical exercises illustrating the subject. By John Perry, M.E., D.Sc., F.R.S., Professor of Mechanics and Mathematics at the Royal College of Science, South Kensington. With 371 illustrations. Pp. viii., 678. Cassell & Co., Ltd. 1897.

In this book Prof. Perry gives the substance of the lectures on Applied Mechanics he has for many years delivered at the Finsbury

Technical College, the portions of the subject which are suitable for an elementary course to first year students being printed in larger type than the more advanced portions.

In addition large collections of numerical and graphical exercises (with answers appended), are given at various stages in the development of the subject. These will prove very useful both to teachers and students.

One of the most interesting features of the book is the description and illustration of several pieces of laboratory apparatus, which have been designed by Prof. Perry for students' use in performing quantitative experiments in Applied Mechanics.

In fact the professor takes up strongly the position of a reformer of the "academic" methods of instruction in Applied Mechanics which he conceives to be in vogue in too many places, and insists on the absolute necessity for students making quantitative experiments in a Mechanical Laboratory as an essential part of any proper course of instruction in Mechanics. He refers with just pride to more than twenty complete sets of his apparatus which have already been made for various institutions, and no doubt the publication of this book will induce many other colleges and technical classes to follow more or less closely his system of instruction.

Prof. Perry acknowledges the pioneer work of Prof. Ball at the Royal College of Science, Dublin, in initiating quantitative experimental work in illustration of the principles of Mechanics. But instead of building up each piece of apparatus out of a small number of elements, which served for many different experiments, Prof. Perry's plan has been to use a distinct piece of apparatus for each experiment (with the obvious advantage of having the apparatus always ready for use), and instead of the lecturer performing the experiment the "student measures things for himself; illustrates mechanical principles; finds the limits to which the notions of the books as to friction and properties of materials are correct; learns the use of squared paper, and the accuracy of graphical methods of calculation; and, above all, really learns to think for himself".

Another excellent feature of the work before us is the freshness of the information and the originality of method obvious on nearly every page. Whilst many teachers will consider the style too polemical for a text-book, and will look on some of the attacks on what are here called "academic" methods, and "academic" persons as uncalled for and quite unnecessary in a "treatise for the use of students," no one interested in the training of mechanical engineers can afford to neglect the results of Prof. Perry's experience as embodied in this treatise.

In regard to the "get up" of the book the illustrations with some few exceptions are very satisfactory, but the paper is too thin, or rather is not sufficiently opaque, and this makes the small type very trying to the eyes; the printing also of the mathematical portions leaves much to be desired.

The importance of the book is such as to justify the hope that the above defects may soon be remedied in a new edition.

Theoretical Mechanics, an introductory treatise on the Principles of Dynamics, with applications and numerous examples. By A. E. H. Love, M.A., F.R.S., Fellow and Lecturer of St. John's College, Cambridge. Pp. xvi., 379. Cambridge University Press, 1897.

The author of this book furnishes mathematical students with an introduction to dynamics which will probably have some considerable influence on the progress of science. For instead of slavishly adopting the principles of Mechanics as laid down by Newton, Mr. Love has not shrunk from independent treatment, and has taken great pains to expound the subject in strict accordance with the best modern ideas.

The language throughout is very carefully chosen. As an example of the way in which precision of statement is attained, we may mention the explicit recognition of three classes of vectors marked by different degrees of localisation: unlocalised vectors, vectors localised in a line, and vectors localised at a point; where in the first class the line representing the vector may be drawn from any point, in the second class from any point in a particular line, whilst in the third class the line representing the vector must be drawn from the specified point.

Instead of the artificial "effective force" which has been so long employed in connection with D'Alembert's principle, the term "kinetic reaction" is adopted. At first glance "kinetic reaction" strikes us as a happy abbreviation for Newton's "reaction against acceleration," but as used in this book it designates the vector localised in the same line and having the opposite sense.

Throughout the work the physical aspects of the subject are kept prominently in view, and the order of difficulty of the physical notions involved determines the arrangement of the several parts of the subject matter. The first part of the book accustoms the student to the idea of acceleration. In the second part the notion of mass is the central idea, and here the general principles of dynamics are expounded and the equations of motion formulated; the theory of work and energy is dealt with in the last chapter of this part. The third part gives the methods of applying the general theory to different classes of problems. First come two chapters on dynamics of a particle, one on free motions, the other on motion under constraints and resistances. Next follows a chapter on motion of a rigid body in two dimensions. This is succeeded by an important and very suggestive chapter on impulses, initial motions, small oscillations, stability of steady motions, the motion of chains, and some further applications of the principles of energy and momentum to systems of rigid bodies.

The concluding chapter contains a critical discussion of points which involve special difficulties when treated from the standpoint of the modern doctrine of the relativity of motion.

An important feature of this book is the series of illustrative problems which are worked out fully in the text.

Large collections of examples are appended to several of the chapters. These examples are carefully grouped, and afford considerable opportunities of choice to teachers and students making this their text-book.

Untersuchungen ueber Bau Kerntheilung und Bewegung der Diatomeen, von Robert Lauterborn. Mit 1 Figur im Text und 10 Tafeln. Leipzig: Verlag von Wilhelm Engelmann, 1896.

This splendidly got up work reflects credit no less on the author than the publisher. The Diatoms have been too long the almost exclusive property of the amateur, but the important results which have been obtained by Dr. Lauterborn can hardly fail to direct new attention to this group of organisms.

After a brief historical account of the work of previous investigators, followed by a general description of the methods which he employed, the author passes on to the results of his researches on various members of the Diatomaceæ, and these results are as surprising as they are novel. Dr. Lauterborn has wisely checked his investigations on the killed and fixed plants, by observations made on living material, and he has also applied the microtome methods with great success in his endeavours to elucidate the anatomical structure, often very complicated, of the Diatom cell. Thus in *Pinnularia*, the "raphe" is shown to represent an open slit which places the protoplasm in communication with the external world, and in *Surirella calcarata* the same end is attained by means of slits which occur at the edges of the four wing-like outgrowths so characteristic of this species.

As regards the structural characters exhibited by the living contents of the cell, Dr. Lauterborn has arrived at several remarkable conclusions and his results will, if confirmed, prove of great importance. For in these organisms, representing a somewhat isolated phylum, only joining the main line somewhere amongst the lower algæ, we meet with a protoplasmic complexity for which we seek in vain amongst the higher animals and plants, finding at most a faint degree of resemblance amongst the protozoa. And, indeed, it is a remarkable fact, if we take a general survey of organic life, that we find the mechanism of cell-division so extremely complex amongst these lower forms, often far more so than is the case with plants or animals far higher up in the evolutionary scale.

Amongst the observations recorded on the mode of nuclear division, Lauterborn mentions that he was able to recognise cross fibrils of protoplasm connecting the aster rays, and he adduces a considerable body of evidence in favour of Bütschli's theory as to the foam-structure of protoplasm. Even in the nucleus, in some instances, he asserts that a foam-stucture can be distinguished, the chromatin particles occurring in the angles where the foam-walls meet. The centrosomes are stated

to be readily discerned and often to be clearly recognisable during life, but it must be stated that, judging from the figures, they do not very closely resemble the centrosomes of such higher plants and animals in which these bodies have been clearly identified.

The most remarkable statements in the book are those which refer to the origin and structure of the spindle. This body is said to arise from the centrosome as a rounded structure, which eventually assumes a cylindrical form, and then penetrates the nucleus, travelling towards it as a perfectly definite entity. When it reaches the interior of the nucleus it increases in size and the chromosomes ultimately become arrayed around it, in a manner similar to that which has been described for some protozoa. The original centrosome, after having budded off the spindle, finally degenerates and new ones are formed from the ends of the spindle towards the close of mitosis. It is suggested that the daughter-chromosomes are attracted chemeotactically towards the poles and are not pulled thither by the contraction of a peripheral mantle of spindle fibres. After the separation of the constituents of the two daughter-nuclei, a cell-wall gradually advances from the periphery, cutting the entire cell into two parts in essentially the same fashion as has been described by Strasburger and others for, *e.g.*, *Spirogyra*.

After the account of the process of nuclear division, which is illustrated by many beautiful figures, the author proceeds to discuss the mode of movement prevalent amongst Diatoms and concludes that locomotion is effected by means of the emission of a mucilaginous substance throught the slits in the shell.

Enough has been said to show that the book teems with new observations and it is to be hoped that other investigators may also be attracted to so promising a field of research as the Diatoms clearly afford, and such is also the desire expressed by the author himself, who thereby proves himself to be superior to that commercial instinct, occasionally to be met with even amongst scientific men, which prompts them to keep to themselves any promising lines of investigation on which they may have lighted lest some one else should happen to infringe on their paltry claims to priority.

APPENDIX.

NOTICES OF BOOKS.

System der Bakterien. Handbuch der Morphologie Entwickelungsgeschichte und Systematik der Bakterien. Von Dr. W. Migula, a.o. Professor an der technischen Hochschule zu Karlsruhe. Erster Band, mit 6 Tafeln. Jena: Verlag von Gustav Fischer, 1897.

Dr. Migula has earned the gratitude of those who, unable by reason of the pressing claims of other work to cope with the hordes of original contributions so rapidly following on each other's heels, yet desire to be placed *au courant* with the main lines of advance in bacteriology. He has not attempted an easy task. The mere working through the steadily increasing literature must have required an immense amount of perseverance, but he has succeeded in giving his readers a fair account of a many-sided subject. Opening with an historical introduction, occupying the first fifty pages or so, he proceeds to give a fairly detailed discussion on points connected with the morphology and development of the organisms themselves. The methods of growing the plants, and the varied conditions of their life, including their influence on the substratum, occupies the concluding chapters of a volume so full of information as to cause one to express the hope that its promised successor will appear as soon as may be. Dr. Migula is decidedly to be congratulated on this first instalment of an important work.

Views on Some of the Phenomena of Nature. By James Walker. London: Swan Sonnenschein & Co., 1898.

The general character of this book is sufficiently set forth in the following extract, taken from p. 187:—

"Light is the combined PLASMA of all the several substances which are in the sun's pyrosphere in an incandescent state, and carried off by a flood of force generated in, and ejected from the sun, and which combination constitutes ELECTROGENE".

A Text-book of Zoology. By T. Jeffrey Parker, D.Sc., F.R.S., and William A. Haswell, M.A., D.Sc., F.R.S. In two volumes. Pp. lvii., 1462. With 1173 illustrations. Macmillan & Co. Price 36s. net.

The appearance of this important work, for which many of us have been eagerly waiting, will be hailed with pleasure, but not, alas, unmixed with sorrow. For almost simultaneous with its publication we have to record the premature death of one of its authors. The late Prof. Parker's earlier works are well known and highly appreciated by all students and teachers, and we believe that the present book, representing as it does the finishing and crowning work of a life devoted to the furthering of biological science, will attain to an equal if not to a greater degree of popularity than that enjoyed by his previous works.

While we cannot avoid attaching this melancholy interest to the book before us, in connection with one of its authors, we must, on the other hand, congratulate Prof. Haswell on the completion of his great task.

Although the scientific papers of this author have long been known to the specialist and advanced student, till now Prof. Haswell has been comparatively unknown to the elementary student in this country.

When we look at the latest editions of our scientific text-books we see all of them steadily increasing in size; this must be inevitably the case with all branches of science that are actively growing. Comforting as these signs of activity may be to the advanced student, the beginner is likely to be terrified when he sees the number of pages which he has to master even to make himself familiar with the rudiments of a science. The present work, we are afraid, will not reassure him in this respect, for it consists of no less than 1400 pages, and yet, as the authors state, is strictly adapted to the needs of a beginner. One must, however, remember that the 1200 illustrations considerably reduce the bulk of the text and renders the same clear and easy of comprehension. Still we cannot help thinking with regret that the large size of this work, and consequent large price, will keep it out of the hands of many of our elementary students who stand in great need of a good text-book of zoology.

For a text-book of zoology our authors pursue a novel course and one that will undoubtedly commend itself to the beginner with no previous knowledge of the subject. An example of each important class is carefully considered in detail before proceeding to formulate the distinctive characters of the group, then follows the classification and a consideration of the chief variations in structure and development met with in the class, and, finally, a paragraph dealing with the interrelations of the different orders, this being in all cases terminated with our old and much-abused friend the phylogenetic tree. Many will no doubt object to these "diagrams illustrating the mutual relationships of the class," but, after all, they are almost necessary for the beginner and serve a useful purpose if the latter will only study the conclusions upon which they are based, and remember that they are only attempts to interpret the known facts of morphology, embryology and palæontology.

For the benefit of the beginner the subject is introduced by a chapter on structure and physiology, and here we must put forward a strong protest against the unfair treatment which the spermatozoon meets with, thus we find it stated that the Metazoa originate from a single cell, the ovum, thus ignoring the cell-value of the spermatozoon and regarding the latter merely as the impulse to development. Surely sufficient is now known of the development of the two sexual cells to prove that the ovum and spermatozoon are morphological equivalents and that the ovum, save in the still little-understood parthenogenesis, can no more give rise to an embryo by itself than can the spermatozoon. The equal value of these two elements might be demonstrated even to the elementary student if the last two divisions of the sperm-cell had been given, in addition to the maturation of the ovum, which, taken alone, is almost inexplicable to the beginner. In this same chapter we find Fol's "Quadrille of the Centrosomes" cropping up again, notwithstanding the fact that Boveri and others have long shown that theory to be erroneous. We sincerely hope this will be removed from the next edition and a less prominent rôle assigned to the centrosome, which is

at last deservedly on the decline, many even of its continental advocates, now show signs of want of faith in its omnipotence.

Botanists, we are afraid, will take exception to the excellent chapter on the Protozoa, where we find such forms as *Hæmatococcus*, *Pandorina* and *Volvox* included as animals. The Mycetozoa are very aptly placed with *Protomyxa*, with which genus they show great similarity in their life cycle. We presume that in the arrangement of the sections the authors pursued some definite plan, but, if so, we utterly fail to fathom the reason for the intercalation of the Echinodermata between the Molluscoida and the Annulata, by this means the Trochelminthes and Molluscoida become completely separated from the Annulata, with which group even our authors consider the Trochelminthes, at least, to be related, as may be seen from the diagram on p. 483. The inclusion of *Phoronis* amongst the Molluscoida is open to grave doubt; and we fail to see why doubt should be thrown on the account of the development of the Endoproctous Polyzoa so ably given by Harmer, and the Ectoprocta, whose developmental history is fairly well known, interpreted as if they developed like *Phoronis*. Of course these forms are particularly difficult to classify in a natural manner, but we do not think that the plan adopted here will commend itself to any who have worked at these groups. The retention of the *Echinridæ* as an order of the Gephyrea is very antiquated and unnatural, for neither in their development nor in their adult structure do they show much resemblance to *Sipunculus*, and they find a much more natural position with the Chætopoda.

It is quite delightful to see such a large number of new illustrations, and as, in many cases, there is a complete description of the anatomy of some hitherto little-known form, now copiously illustrated, these will be of the greatest value even to the most advanced student. Amongst these we would especially draw attention to the description and illustrations of the anatomy of the Starfish (*Anthenea acuta*), of *Nereis*, of *Triton nodiferus*, and of *Nautilus* amongst the invertebrata, while among the vertebrata we find excellent accounts of fish which to us are rarities, *viz.*, *Callorhynchus* and *Chiloscyllium*.

Judging from the statements in the preface (p. viii.) we should not have expected our authors to adopt any views which had not stood the test of time, but in dealing with the mammalian dentition we find them adopting the unsupported views of Wilson and Hill, which are at variance with all those of the numerous European workers, many of whom have spent years in the study.

The wealth of illustrations is wonderful, and these have for the most part been judiciously chosen, but a few are not quite so happy. Fig. 453, for instance, is a shocking misrepresentation of a cockroach, and would certainly give the beginner the idea that the wing cases were attached to the pro- instead of to the meso-thorax; fig. 510 also is misleading, and the elementary student who had never seen a *Limulus* would certainly receive the impression that this animal had a pair of large compound eyes situated close to the middle line. Surely, too, our authors have made a slip of the pen in labelling the figure of a mosquito as *Pulex*, or has some industrious systematist been digging in the dust-

bins of the past and found a fresh name for the gnat. Systematic terminology is always a trial to the general zoologist, but whatever terminology is used it should be uniform, and it is a pity to find the same animal posing under two distinct names, as we find the common English earthworm as *Lumbricus herculæus* and *L. agricola*, the latter, according to Benham, being a synonym for the former.

In conclusion, we should like to draw especial attention to the chapters on Distribution, the Philosophy and the History of Zoology, a novel and extremely useful addition to a work on zoology. In the comparison of the animals of Britain and New Zealand it is stated that land Planarians are unknown in the former. Although this is generally thought to be the case it is not really so, a land Planarian having been long ago described from England, and more recently from Ireland. It is, however, not to be wondered at that some small errors should creep into a work of this size; and when we consider the difficulties under which these authors laboured, one in New Zealand the other in Sydney, the printers, publishers and artists in England, one can only marvel at the splendid work they have produced, one that will be useful both to the elementary and advanced student alike as well as to the teacher.

The Outlines of Physics, an Elementary Text-book. By Edward L. Nichols. Pp. 452. New York: The Macmillan Co., 1897.

In his preface the author says that this book is intended as a short course in physics which should be a fair equivalent for the year of advanced mathematics now required for entrance to many colleges. If this is so, then the "advanced mathematics" must be of a decidedly elementary character, for this book is quite elementary.

The work belongs to that class which combines the functions of a text-book with those of a laboratory-manual. The chief objection to the book as a text-book is that on account of want of space the author has hardly been able to treat the subject sufficiently fully for even an elementary class.

The experiments described are in general of such a character that they can be performed without the use of expensive apparatus, and are chosen so that a quantitative result of some kind is to be obtained. In this connection our experience leads us to think that it would have been of much use if the author had devoted a section to the consideration of the method of roughly determining, from the accuracy with which each of the quantities which are actually measured can be determined, the accuracy that can reasonably be expected in the result. The increased importance of the errors made in the measurement of a given quantity if it is involved in the final expression to the second or higher power ought also to be insisted upon, even at the first.

The author being a fellow-countryman of Rowland it seems strange that the value 772 for the mechanical equivalent of heat is given, although it is now known that even Joule's results give, when corrected for errors in his thermometry, a much higher value.

The figures are on the whole excellent, for they are clear and show

how the apparatus is to be put together. There are, however, two conspicuous exceptions in figs. 137 and 147, in which the bends in the glass tubes will certainly incite the beginner to make even a worse pucker than usual. A full-page picture of the tower of Pisa is also hardly in keeping with the other figures.

On the whole the book will be found very suitable for those who require a book which combines the characteristics of a decidedly elementary text-book with those of a good laboratory-manual.

Theory of Electricity and Magnetism. By Charles Emerson Curry, Ph.D. With a preface by Prof. Boltzmann. Pp. 442. London: Macmillan & Co., 1897.

This work embodies the substance of the course of lectures on Electricity and Magnetism given by Prof. Boltzmann at the University of Munich, Dr. Curry having, however, considerably amplified the lectures and added examples and deductions for illustrating the subject matter.

The characteristic of the author's method of treating the subject lies in that starting with the differential equations of the electromagnetic field he then proceeds to deduce from them the explanation of all electric and magnetic phenomena, by means of mechanical analogies, and in this he follows a course quite different from that adopted in the class of text-book in favour in this country. This method of procedure of course necessitates, on the part of the student, a considerable acquaintance not only with the experimental part of the subject but also with the theories of the subject. The work forms in fact an illustration of the standpoint from which the theory of electricity and magnetism is studied on the continent, and will be found of much use to those whose physical and mathematical equipment is sufficiently good.

Starting with the assumption that in every volume-element of the ether a motion exists, and that it is to this motion that electric phenomena are due, and that further the displacement produced by this motion can be represented by a vector which he calls the "tonic vector," the author by making certain assumptions as to the connection between the kinetic and potential energy, etc., and this vector deduces by means of Hamilton's principle the equations of the motion of the ether. By a slight modification these equations are then reduced to Maxwell's form.

In the interpretation of the equations the conception of two incompressible fluids, the positive and negative real electricities, is introduced, together with the idea of free electricity and of electrical polarisation. As an analogy simply meant to illustrate the subject this may be all right, but as a physical theory it is of little use.

After considering Maxwell's form of the equations the author goes on to show by what assumptions and in what manner they may be converted into Helmholtz's form. He also shows how Helmholtz's equations may be deduced from the empirical laws. The subject of Hertzian waves, of the propagation of longitudinal ether waves and of electric and magnetic striction are also dealt with.

The reasoning is on the whole clear and explicit, and the book is remarkably free from errors.

Catalogue of the Fossil Cephalopoda in the British Museum (Natural History). By Arthur H. Foord and George Charles Crick. Part iii. London: Printed by order of the Trustees, 1897.

Catalogue of the Tertiary Mollusca in the Department of Geology, British Museum (Natural History). Part i., *The Australasian Tertiary Mollusca.* By George F. Harris. London: Printed by order of the Trustees, 1897.

Specialists will welcome the appearance of two more volumes dealing with the extensive collections of Fossil Mollusca in the British Museum. The third part of the catalogue of fossil Tetrabranchiate Cephalopoda treats of a family of the Nautiloidea which had not found a place in the first two parts, as well as of the first instalment of the Ammonoidea. The authors agree with Haug in abandoning Fischer's subdivision of the Ammonoidea into Retrosiphonata and Prosiphonata. The classification of the Goniatites adopted is based on that proposed by Prof. Alpheus Hyatt, and the suture lines characteristic of the individual species are illustrated by cuts in the text which will prove invaluable for the identification of specimens by those who are unable to obtain access to the types. It is a matter for congratulation that Dr. Foord has found such an able *collaborateur* and successor in the person of Mr. G. C. Crick.

Mr. G. F. Harris's catalogue is to be the first of a series devoted to the fossil faunas of special geographical regions; dealing as it does with the tertiary mollusca of Australia and New Zealand, with Tasmania and the Chatham Islands, it will supply the student of distribution with a store of facts which will be of the greatest service to him in solving the problem of the past history of the present molluscan fauna. A prominent feature of the work is that the author has devoted especial attention to the growth of shells. The very remarkably perfect state of preservation of the gasterpoda of Victoria and elsewhere has enabled him to show that in many cases distinct modifications of structural detail are mere peculiarities of stages of growth, and are not necessarily of classificatory value. In the introduction the reader's attention is drawn to a few of the more interesting points; but it is a pity that no indication is given to the new names and new species which appear in the work; an asterisk affixed to the names in the index or table of contents would have been of great assistance to the reader or recorder who is desirous of ascertaining the exact contributions which the author considers that he has made to scientific nomenclature. Of great value are the eight excellent plates of illustrations drawn by Miss G. M. Woodward.

*Lehrbuch der vergleichenden Mirkroskopischen Anatomie der Wirbelthiere. Z*weite Teil. Schlund und Darm. Von Dr. A. Oppel, a.o. Professor a.d. Universtät Feiburg i. B. Jena: Gustav Fischer, 1897.

During the last two decades discovery concerning the anatomy, histology and functions of the vertebrate alimentary system has

advanced with great rapidity. The work of Edinger and others on the intestinal epithelium of fishes, of Bizzozero and his followers on that of the tubular intestinal glands, the discovery of a true pancreas in the bony-fishes, of pancreatic and splenic tissues in the dipnoi lying wholly within the wall of the gut, and of the compound origin of the pancreas in representative species of the several great groups of vertebrates, together with observations on the functional side no less welcome and important, have brought harmony into confusion and simplified our conceptions not a little, necessitating a stocktaking of the sum of our knowledge in this generally interesting department. To Dr. Oppel has fallen the task of meeting the latter demand, and the present volume is the second of two which he has devoted to the purpose, the first (on "The Stomach") having preceded it by but a year. Contrary to what might be expected, the work thus rapidly issued, is exhaustive, most carefully executed, and thoroughly reliable, and there is evidence of its having occupied its author's attention for several years. Its 664 pages are amply illustrated by 343 well-chosen text-figures and four plates of great excellence. A full bibliography and analytical indexes are given, and the pages of the work are thoroughly salted with references. The whole arrangement is a well-conceived one, whereby the reader is without difficulty enabled to ascertain precisely what has been observed concerning a given species, and where to turn for fuller information upon details. The book is in fact the embodiment of our ideal of the work of reference which we believe the advanced text-book in Science of the future must become. The author has solved the problem of compressing within reasonable limits and presenting in a thoroughly workable form the sum of our knowledge of a vast subject, and that more successfully than most with whose books we are familiar. We note the omission of some few references and of topics which might well have been considered, but all that is leading and important is there. The compilation of works of this order has now become a necessity if energy in the future is to be economised and directed into the channel best conducive to advancement, and to those disposed to enter upon the task of ensuring this, Dr. Oppel's book may well be recommended as a pattern.

The Tailless Batrachians of Europe. Part i. By E. A. Boulenger, F.R.S. London: The Ray Society, 1897.

This book, primarily intended for the English scientific public, deals with a group of animals ever popular and conspicuously associated with the work of English-speaking zoologists. Its 204 pages are illustrated by seventy-seven processed drawings, and nine plates, of which six are coloured, and by two maps; and we have no hesitation in stating that it is one of the most important additions to zoological literature during recent years. It deals comprehensively in its "Introduction" with the Amorous Batrachians, classified according to Cope's system, which all recent investigation has gone to support, and categorically in the eighty-eight pages which follow with the *Discoglossidæ* and *Pelobatidæ*, the latter mode of treatment of the

remaining families being reserved for the second part, now we believe in an advanced state. Habits, structure, reproduction and metamorphosis, and geographical distribution, all receive adequate attention, and are described in popular terms in a manner permitting of ready service in either the field or study; and an enthusiastic keynote struck in the preface pervades the book from cover to cover, author, artists, and all concerned having combined to produce a work which, while marking a new departure of the Ray Society, will perhaps do as much towards encouraging a love of field natural history as any work of its time. The author is notorious for his painstaking enthusiasm as a zoological investigator, even a holiday being to him of no avail unless he have access to the haunts of his favourite animals, and in the pages of this book we find combined with much that is technical and which, as published elsewhere, has helped to render him famous, a vast accumulation of observations made during holiday-time which, while materially extending our knowledge of local distribution and habit, by its very nature appeals the more directly to the outdoor naturalist and passer-by. The weakest portion of the book is the anatomical. The author professedly ignores the anatomy of the nervous, higher sensory, and circulatory systems, and of the soft parts other than the lungs and urinogenital organs, for reasons duly given; but as concerning the latter, confusion for which the author is little responsible appears to have arisen in the description of the "vesicula seminalis" *vas efferens* and their alleged relationships to the genital ducts and omission in that of the vestiges of the latter in the male Rana, while in the general anatomical terminology considerable revision might be highly advantageous. When critical, the author brings to bear the full force of his lengthened experience with marked effect, as, for example, in his denunciation of the popular belief that the tadpole metamorphosis is recapitulatory of phylogeny, which we most heartily support. The book is what it professes to be, and by its aid the wayside naturalist should find no difficulty in determining the species and all that is important for taxonomic study of our European forms. To the field naturalist it will be indispensable, and without it no zoological library can be complete. Of all branches of science the zoologists is the most humanising, and it is by works such as that now under review that the mind may be most readily awakened through the beauties to the more philosophic aspects of vital phenomena, the fuller study of which affords a mental discipline second to none other and a means of happiness as inexhaustible as it is beneficial. We eagerly await the appearance of the second part, and regard it a national duty of the Ray Society to provide, if possible, for a third or fourth part, which shall be devoted to the tailed Batrachians, especially since recent study of them has revealed structural and functional conditions unique and unsuspected, such as are pre-eminently calculated to arouse the real appreciation of the instructive in Nature through the gratification of the desire for the sensational and curious, always present in the public mind.

APPENDIX.

NOTICES OF BOOKS.

Practical Acoustics. By C. L. Barnes. London: Macmillan & Co. 1897.

This volume forms the first instalment of the long-promised third volume of Stewart and Gee's *Lessons in Elementary Practical Physics.* To those who have been in the habit of using the previous volumes the present addition will probably prove very disappointing, for the character of the book is entirely different. This is no doubt partly due, as the author explains in his preface, to the difficulty in the subject of acoustics of devising quantitative experiments which can be carried out in a laboratory having the ordinary equipment. One of the chief defects of the book is that it is swamped with the description of experiments which, although they are in many cases curious and interesting, are perfectly unsuited for an educational work. In some cases experiments are described which have not been explained, and which do not illustrate any special portion of the subject. These experiments might have been collected together in an appendix without much harm, but scattered as they are throughout the book, they seem to give the idea that the performance of pretty experiments is the aim and object of the work.

In many places the working or definitions are very obscure. Thus to define the amplitude of a vibratory motion as "The displacement of an antinode from its initial position" seems to restrict the definition to a certain portion of a stationary wave, while the next sentence says, "the mean velocity of each particle is proportional to its own amplitude". The statement on page 27 that the frequency of the transverse vibrations of a string varies directly as the square root of the tension, is followed by the following paragraph: "It also varies directly as the square root of the force of gravity, but this is commonly left out of account". These two statements are perhaps as thoroughly vicious and calculated to confuse the student as any that could be compiled. Again, Young's modulus is defined as the ratio of a small increment of pressure to the resultant diminution of length. In using the word tension when he means stretching force, the author follows a somewhat general practice but one none the less to be regretted.

The book as a whole suffers from undue expansion on the one hand and from looseness of expression on the other, so that although it will probably be found useful for teachers and others in quest of lecture experiments, it is hardly a safe book for the use of the, at any rate the elementary, student of physics.

Dictionnaire de Physiologie. Par Charles Richet, avec la collaboration de MM. P. Langlois et L. Lapicque, etc. Tome II., fascicules 2 et 3. Tome III., fascicule 1. Paris: Ancienne Librairie Germer Baillière et Cie. Félix Alcan, Editeur. 1897-98.

One of the most salient features of the above portion of this work is the unequal nature of the articles. It may be that, perhaps, this is due in great measure to the method of production, *viz.*, the entrusting of special sections to special authors. And yet it is a method which, properly carried out, seems capable of giving the very best results, and in text-books and important works on science at the present time the method is being adopted more and more frequently, and often with great success.

Nevertheless it is unavoidable that the method should sometimes fail, and this more particularly if the very fullest instructions have not been provided for the separate authors as to the scope and length of their respective sections, and in the earlier portions of a work like the present one might expect to find a certain disproportion in the articles, but in later parts—and the work has now reached the eighth fasciculus—one is justified in expecting to find more uniformity.

Such however is not the case, and we can only regret the circumstance.

In the article headed "Calcium," occupying seventeen pages, there appears a good discussion of this metal, its occurrence in the organism, its relations to the skeleton in various animals, vertebrate and invertebrate, and its absorption and excretion.

No discussion of its *rôle* in coagulation is given, this being deferred to the articles on Milk, Coagulation, and Blood.

The article on the Cell is particularly disappointing, for we looked forward to finding a thoroughly good discussion of this most interesting subject.

The article occupies only forty pages, and compares very unfavourably with the two very lengthy dissertations on the Brain, which covers 486 pages, or with the Heat, which occupies 190 pages. Moreover, we do not consider that the best use has been made even of this limited space. Section 1 of the article bears the title "Morphology," and occupies three and a half pages. The nucleolus is described as usually occupying an excentric position in the nucleus, as being rounded or oval, and more highly refractive than the latter; as staining more intensely than the nucleus, as comporting itself differently to certain reagents, as having an unknown significance, as disappearing during cellular division to reappear in the young cells, and—that is all!

The centrosome is treated with scarcely more ceremony, and this in spite of the date—1897—on the cover of the book.

We wish to enter an objection against the practice—very much to the fore in this article—of printing the same figure twice or three times, on each occasion with a new number and with no indication that it has

appeared previously. Here we see figures 38, 39, 40 and 41, repeated as figures 44, 45, 46 and 47, whilst the figure originally appearing as fig. 36, does duty no less than three times. No doubt it is convenient to have the drawing on the same page as the letterpress referring to it, but in the present instance, at any rate, we think that space might well have been economised, even at the sacrifice of convenience.

In the other sections things are scarcely more satisfactory. The description of indirect division of the nucleus is short, bald, and utterly insufficient, there is practically no discussion, and no mention of many most important points.

It is perhaps significant that the bibliography includes thirty-two references only, and that amongst these there does not occur the name of a single English or American author.

In the next important article—that on the Brain—an excellent account of most of the known facts is given, and in the space of nearly 500 pages a mass of information is collected and arranged in such a way as to form a most useful storehouse, to which constant reference will undoubtedly be made.

The article opens with a historical sketch of 120 pages, then follow seventy-four pages on General Morphology, and a section on the cerebral circulation.

The bibliography of this section seems particularly full and up to date, the titles of most of the important papers which appeared in 1896 being inserted.

The rest of the article on the general *rôle* of the cerebral cortex, the cortical centres, and the conducting functions of the brain, are all well and fully treated, but unfortunately the bibliography has been somewhat neglected, and this is the more important in a book which one would naturally turn to for a full and representative list of papers.

In the article on Heat again we have a fairly complete and exhaustive account of the subject, and the first section on Heat Production in living beings has a bibliography extending to nine pages. Then follows a short section on General Biology, and in section 3 we have an account of the action of heat on living beings, with a bibliography of twelve pages.

For these two important articles then we have nothing but praise;—they are worthy of the work in which they appear, and will prove useful to physiologists for many years to come. As regards the rest of the articles most of them are sufficiently fully treated, or at all events as fully as their importance justifies when space is limited—but we must repeat that in a work like the present, that although of course there cannot be included exhaustive accounts of every point in physiology, yet there ought certainly to be given in every case a full bibliography, and the editor would do well to insure such being provided in future sections.

Open Air Studies in Botany. By R. H. Praeger, B.A., B.E., M.R.I.A. London: Chas. Griffin & Co., 1897.

The idea of this book is distinctly good. It is of course not quite original, having already been developed by Warming and others. The author's aim is to give an account of the characters of the flora of a locality regarded from the standpoint of the physical conditions there prevalent, and he has wisely refrained from attempts at too ambitious a treatment. Thus he selects types such as a meadow, an alpine, a bog flora, and treats of those constituent plants which may be found growing at a particular season. In fact the book forms a series of excursions, and as such it will be of use in indicating not only the general character of a physical flora, but also what time of year it may most advantageously be visited. A good feature of the volume lies in the photographs of plants in their natural surroundings, but the reproductions are not very successful in every case. The glossary is perhaps the weakest part of the book, many of the definitions as they stand, if not actually erroneous, are at least misleading. These defects ought to be remedied in a new edition if it should be called for. On the whole the book is useful and interesting, even where one does not agree with the writer's statement or opinions.

Lehrbuch der Botanik für Hochschulen. Von Dr. E. Strasburger, Dr. Fritz Noll, Dr. Heinrich Schenck, Dr. A. F. W. Schimper. Dritte verbesserte Auflage, mit 617 z. th. farbigen Abbildungen. Jena: Gustav Fischer, 1898.

Students of Botany will welcome the new edition of the "Bonn Text-book". That the book has achieved success is abundantly proved by its having passed into the third edition in less than four years, and we may add that its success is well deserved.

The original plan was excellently conceived and its execution has been materially improved in its present form. A few new illustrations meet the eye of the reader, whilst some of the old ones have been replaced by better ones. Amongst the latter, we notice that the centrospheres and centrosomes are now absent from the Phanerogam cell. The text also has been brought up to date, thus recognition is accorded to Williams' recent work on the Dictyotaceæ.

A bibliography at the end of the volume will prove a useful addition, though it might, perhaps, have been with advantage distributed through the various sections to which it respectively belongs. Altogether the authors and the publisher may be congratulated on having produced one of the best botanical text-books of its grade in existence.

A Student's Text-Book of Zoology. By Adam Sedgwick, M.A., F.R.S. Vol. i. Pp. xii., 619. With 472 illustrations. London: Swan Sonnenschein & Co., 1898.

As Prof. Sedgwick states in his preface, this work is intended to replace his translation of Claus' *Lehrbuch*, and is consequently prepared upon the same lines.

This book is not intended for the elementary student, nor is it written as a practical laboratory guide, but it is thoroughly suited to the needs of the more advanced students in their second and third years, and to all those who have some general knowledge of zoology. And further, the inclusion of so large a number of genera, even though many of them are merely mentioned by name (the index covers twenty-seven pages, which gives some idea as to the great number of forms dealt with) makes this work an extremely useful book of reference to all interested in Natural History.

We are glad to see that Prof. Sedgwick has so far omitted the usual introductory chapters dealing with the principles of zoology, these in his translation of Claus' *Lehrbuch* occupied 181 pages, and consequently curtailed the systematic part of the book considerably. We hope Prof. Sedgwick will reconsider his determination to introduce this matter into his second volume, and that he will rather allow his second volume to follow on the lines of his first. When this is complete, let him by all means write us a book on the principles of zoology, for which, we believe, there is great need; but let it be a book all to itself, the subject being one that is too important to be treated, as is usually its fate, in a few chapters appended to a systematic text-book, which necessitates one or other of the parts being unduly curtailed.

One short introductory chapter, however, appears to us to be needful, setting forth Prof. Sedgwick's views upon the cell theory. Our author appears to imagine that all students are brought up to believe in the views on this subject which he has so ably maintained in various papers published in the *Quarterly Journal of Microscopical Science*, and that these views are universally accepted. Hence in his introduction to the Protozoa and Metazoa, he most carefully avoids all mention of the word cell, a state of affairs which, we are afraid, will tend to perplex a great many students, whereas a brief statement of his views on this subject would have saved the student much unnecessary worry besides bringing clearly before him a very important interpretation of the animal body, which has no doubt in the past been obscured by a too rigid adherence to the cell theory of the older zoologists.

It is, of course, impossible for one man to be a specialist on every group of animals, and Prof. Sedgwick is to be congratulated on having secured the co-operation of so many able zoologists—to whom he gives due credit in his preface—to assist him in revising special parts of this work.

To deal with a few points in detail, we could wish that a little more space had been devoted to the Calcarea among the sponges, as this group so beautifully illustrates the possible lines of evolution of the complex sponge organisation, and especially that a few more figures of the anatomy of these forms had been given, such, for instance, as *Leucoselenia*, etc., with some reference to Minchin's admirable work on this group.

The book would be improved by the addition of a few more illus-

trations, especially of anatomical points bearing upon the classification of the orders. For example, we find Bürger's classification of the Nemerteans adopted, which, as is well known, is largely based upon the relations of the nervous system to the muscular layers of the body wall, but not a single figure is given in illustration of this important point.

Prof. Sedgwick justly lays great importance upon the presence of a true cœlom, but there are certain disadvantages in the present state of our knowledge attending the adoption of the cœlomata as a group of the Metazoa, for it causes a complete and wide separation of the Rotifera from the Annelida, whereas judging from the striking structural resemblance of certain of the former with the trochosphere larva of the latter group, one would have been inclined to place them close together, and when we remember that the development of the sexually produced embryo of the Rotifera is still unknown, and consequently also the true origin of its body cavity, it seems somewhat premature to so widely separate these two groups. The fact that in the adult Rotifera and Nematoda neither the excretory nor the generative organs appear to be connected with the body cavity, does not entirely preclude the possibility of the latter being a true cœlom, therefore it appears to us that Prof. Sedgwick's adoption of the group cœlomata, however prophetic it may be, is nevertheless distinctly premature and inadvisable in a student's text-book.

We do not think that the majority of molluscan specialists will agree with our author in his severance of the Chitons from the Solenogastres, and to state that such an association was "quite unjustifiable" and of the latter that "they are not Gasteropoda," when we consider the eminent malacologists who have grouped them together, appears to us to be hardly supported by sufficient evidence, and Prof. Sedgwick goes further and throws out a suggestion that the Solenogastres may not be mollusca at all. The main reason given being that the gonads in the Solenogastres open directly into the pericardium, but, as Prof. Sedgwick points out in other parts of this book, the latter is only part of the cœlom in connection with which the gonads are invariably developed, and with which the perigonadial cavity communicates through the kidney (another part of the cœlom) in *Fissurella*, *Haliotis*, some Lamellibranchs and more directly in the Cephalopoda, and when we consider the similarity of the nervous system of the Solenogastres with that of Chiton, the condition of the foot in *Cryptochiton* and that of the organ believed to be its homologue in *Neomenia*, and the many other points of resemblance, I think the majority of us would conclude that the group Amphineura was a natural one, and that at all events the Solenogastres were mollusca, and found their nearest relatives in the Polyplacophora. A few more anatomical illustrations might well have been accorded to this group, and a reference given to Simroth's fine work on these forms in Bronn's *Thierreich.*, Bd. 3., Abth. 1.

The molluscan part of this work is by no means the most satis

factory, and we hope in the next edition of this work to see it revised by a specialist. Prof. Sedgwick has adopted many of Pelseneer's beautiful figures, but he has retained one or two inferior ones, notably fig 282, the nervous system of *Paludina* after v. Jhering, in which the otocysts are represented as innervated from the pedal ganglion which, as our author must be aware from his statement on p. 367, is a mistake, and one which any one can verify in a moment by dissecting a *Paludina*, or by referring to Bouvier's great work on the nervous system of the Gasteropoda (*Ann. Sci. Nat.* (3) iv., 1887), which might well have been quoted here. In connection with the Mollusca, we should like to draw Prof. Sedgwick's attention to a small mistake on p. 336, where in speaking of the relation of the heart and rectum in certain Lamellibranchs he states exactly the reverse of what he meant to say, the rectum in *Ostrea* being dorsal to the heart and in *Arca*, etc., ventral, and not the reverse as stated.

When one considers the enormous work involved in writing a book of this description, one marvels at the accuracy and freedom from mistakes which this text-book exhibits, it should prove of great service to all students of zoology. We must congratulate Prof. Sedgwick heartily on the appearance of this volume, and hope soon to welcome vol. ii.

Lehrbuch der Entwickelungsgeschichte des Menschen. Von Dr. J. Kollmann, o.ö. Professor der Anatomie in Basel. 8vo, pp. xii., 658. With 386 figs. Jena: Gustav Fischer, 1898. Price 15 marks.

When we consider the somewhat limited material from which a student of Human Embryology can draw his knowledge of this subject, we must congratulate Dr. Kollmann upon the excellent work which he has produced. But we fail to see the need of these large works upon Human Embryology; a short work suited to the needs of a medical student we could appreciate, but large books like the present or such a work as Minot's *Human Embryology*, if they really dealt with the human subject alone, can fill no real void. It is the title of these works, however, that is at fault, they are in reality text-books of vertebrate embryology, making a speciality of the mammalia and including most of what is known concerning the development of the human subject. And this must necessarily be the case, for no matter what organ or what developmental point of real significance we choose to study, it would be impossible in the present state of our knowledge of Human Embryology, and possibly always so, to understand the importance or the real meaning of the facts which we might observe, without a thorough knowledge of the Comparative Embryology of the vertebrata generally.

The present work, while introducing a considerable amount of comparative embryology, especially in dealing with the formation of the germ-layers and of the first rudiments of the organs, restricts itself as far as possible to the human subject and deals very fully with the

building-up of the human organs and traces them to their definite form. Especially excellent in this respect are the sections dealing with the blood vessels, the urinary and genital organs; in the latter we find the recent work of Keibel given due prominence. That, however, dealing with the development of the genital products is not so good, the formation of the spermatozoa being treated with undue brevity and its comparison with the maturation of the ovum being overlooked.

We should have thought that some of Heape's work on the germ-layers in the Mole might have been included with advantage in this book, and surely also the student of human embryology should know something about the condition of the ovum in the Monotremata which throws so much light on the peculiar processes met with in the segmentation of the ovum of the Placentalia.

A large series of beautiful process blocks, many of which are coloured, illustrate this work, and among them we find many new and useful figures, especially in the more anatomical part of the book.

The book should be of great use to the student of human anatomy and embryology, but it is too specialised and lacks the comparisons necessary to any one making a general study of vertebrate embryology.

The Romanes Lecture, 1898: *Types of Scenery and Their Influence on Literature.* By Sir Archibald Geikie, D.C.L., F.R.S. London: Macmillan & Co., 1898.

The question treated in the Romanes lecture for the current year is one possessed of a more directly human interest than is the case with many scientific discussions. Sir Archibald Geikie traces, with necessary brevity, the influence of scenery on the minds of some of our great writers. None can doubt the reality of such an influence on all persons with a spark of imagination in their composition, but it is interesting to find it carefully followed and proved in the case of writers like Cowper as the type of the English lowlands and of Burns as representing the Scotch lowlands. The author classifies the characters of scenery into Lowland, Upland and Highland. In his treatment of the last-named group he adduces the poems of Ossian for Scotland and of Wordsworth for North-west England. If it is not possible to criticise in detail a lecture into which, as Sir Archibald himself says, subject matter for a whole course has had to be compressed, it is needless to add that it will be found full of interest for the general reader, and that merely as a study of English composition and style it will well repay a perusal.

APPENDIX.

NOTICES OF BOOKS.

The Tailless Batrachians of Europe. Part ii. By G. A. Boulenger, F.R.S. London: The Ray Society, 1898.

The present year will be memorable in the popularisation of Zoology, if only for the appearance of this splendid and inspiring treatise, now complete. The part before us, paged serially with its fellow, deals on the same lines as that with the Bufonidæ, Hylidæ, and Ranidæ, and there are given in illustrations fourteen plates, four maps, and forty-four text figures, all of which are worthy the text and the preceding part which has everywhere been hailed with acclamation. Concerning the general merits of the work, we have nothing to retract from our wholly laudatory comments upon the first part. All that is important in taxonomy and distribution, and of interest concerning breeding habit and racial varieties, has, up to the requirements of the work, been collected together and presented to the reader in a form well calculated to arouse his enthusiam and interest in the familiar though much despised Frogs and Toads. And for the English student the book has an especial value, in being based upon the matchless collections preserved in our own Natural History Museums, a full list of which is appended. It teems with originality, and one of its most conspicuous features is the recognition of observations on habit and geographical limitation made in the field of the self-trained nature-loving traveller, who, in our present severely academic days, is apt to be considered unscientific, and thereby discouraged in what the perusal of the pages of this book amply proves to be good and useful work. It is for such as these that the book and its companion volume are primarily intended and most heartily do we congratulate both the author and the Ray Society upon their completion. In publishing them they have set up a high standard, and we would reiterate the hope that they will with as little delay as possible follow up this their new venture, and provide correspondingly for the treatment of the Tailed Batrachians, which in many points of popular interest and scientific value even excel their tailless allies.

Die Zelle und die Gewebe. Grundzüge der Algemeinen Anatomie und Physiologie. Zweites Buch. Algemeine Anatomie und Physiologie der Gewebe. Von Prof. Dr. Oscar Hertwig. Jena: Gustav Fischer, 1898.

Every one who has read the first volume of Prof. Hertwig's *Zelle und Gewebe* will open the second part with an assured feeling

that he is going to be interested. And the perusal of the book will not disappoint the reader's expectation.

The author discusses the nature and the complex interaction of the causes which operate in effecting the development and the diversity of organic forms, and thus at once brings us face to face with problems no less interesting to the morphologist than to the physiologist. Opening with an account of the morphological and histological peculiarities of tissues Dr. Hertwig proceeds to examine them from the point of view of the functions they severally discharge. He critises acutely the reasoning of writers who are ready to refer all the phenomena of life to processes analogous to those exhibited by a machine, and points out some of the insidious fallacies which underlie such comparisons.

He insists strenuously on the fact that there are two distinct factors, both of which modify the course followed by the constituent cells of a developing organism; first, the *external*, and second, the *internal* factors. And he well brings out the point so vitally important for his own theory of organised development, namely, that the very presence of a number of cells in a multicellular individual must cause a reaction amongst themselves, since each one is environed by all the rest. Of course this was pointed out by Herbert Spencer many years ago, but it has not always received the attention it deserves, and in fact it is deliberately ignored in one of the most carefully worked out of the current theories of heredity. It may be remarked in passing, that Prof. Hertwig might have considerably strengthened his case for the actively modifying effect of the environment by a reference to Klebs' recent work on algæ and fungi, in which the various factors which determine this or that course of development have been successfully distinguished and isolated.

The *internal factor*, however, it must be confessed, still remains as great a puzzle as ever. We are really totally ignorant of the nature of the causes which determine the development of this or that animal or plant out of apparently similar primordia. Nor are we possessed of any definite knowledge as to the nature of the processes which we term *correlative*. Of course it is clear that a correlation between the various constituent cells of an organism must and does exist, but beyond this we know very little. In the animal world, the experiments of Driesch, Wilson and others on embryos have considerably broadened the basis of facts, but, without in the least desiring to detract from their importance, they cannot be said to have done much more. It is, moreover, not unlikely that the production of "identical twins" in the human species may be due to the separation and independent development of the halves of a fertilised ovum which normally would have developed into one individual, the two halves sinking their separate individuality in producing the single child.

In the vegetable kingdom the zygotes of some fungi and algæ may either grow out directly into single embryos, or they may give rise to several embryos apiece if the first formed cells separate from one another

and become independent—that is to say, instead of a common and correlative development giving rise to one organism, an individualistic segregation occurs amongst the first-formed cells and produces a number of separate plants—and analogous cases are met with even amongst gymnosperms. What nature has done in these plants man, as already stated, can accomplish by the employment of special means, in the case of some animals, though of course the results are not so perfect. But in principle they are probably not dissimilar.

To return to Dr. Hertwig's book, we find that he admits, as essential to his theory of Biogenesis, the existence of two substances which together make up the living substance. The first, the hereditary and governing substance, he calls Idioplasm, following in Nägeli's footsteps, whilst he also postulates the existence of a "Formed matter" (Beale) or *Protoplasma-product*. The latter is moulded by the idioplasm, and is caused by it to assume the particular character distinctive of the various cells and tissues of the body.

But this separation or distinction of the living substance into idioplasm and formed plasm is, under various guises, common to most of the more recent theories put forward to explain the εἶναι and γίγνεσθαι of organic life, nor do we find anything strikingly novel in the notions that not only is the idioplasm the substance conserving the hereditary qualities of the species, but that also it is capable of receiving impressions from without, and thus, itself being altered, modifying its action as the formative material of the cell. Indeed, Dr. Hertwig expressly admits the possibility of the inheritance of acquired character, but regards such inheritance as an important fact with which his theory of Biogenesis is competent to reckon. Nevertheless, the examples he quotes are singularly unconvincing. That "attenuated" bacteria may reproduce attenuated forms is really not to the purpose, since there is no sexual propagation in these forms, but merely an increase of cells resulting from vegetative activity. One might as well attempt to base an argument as to the inheritance of acquired characters on the behaviour of a rose-bush manured in one year and starved in the next. The rose-bush *cells* will, it is true, not be the same in the successive seasons, but the different results in the case of the new starved tissues have no sort of bearing on the inheritance or non-inheritance of acquired characters in the sense in which these are ordinarily defined and understood. And the different bacterial generations are really analogous to the new generations of the rose-bush (somatic) cells.

And the other instance quoted by the author in support of the transmission of acquired characters seems, to the present writer, rather to tell against the assumption that the *hereditary substance*—the idioplasm—was in any way really affected. This instance referred to is derived from the researches of Ehrlich upon the action of Ricin on mice. This investigator found that it was possible to immunise these animals by slowly rendering them accustomed to the poison, and, further, that this immunisation could be partially transmitted to the

offspring. Hertwig (drawing his own conclusions, which differ from those of Ehrlich) seizes on the latter point and regards it as an example of inheritance of acquired characters, but it would seem that it is possible to explain the facts quite differently. For it is only the *female* which can transmit the immunity, and even then it only persists for a limited period of the early life of the offspring. Now it is curious that the male has no such power, but it should be remembered that the sperm consists almost entirely of nuclear idioplasmic matter. The egg, on the other hand, contains in addition a relatively enormous mass of non-idioplasmic protoplasm, and it seems likely enough that, just as the protoplasm of the body cells of the parent was rendered immune, so also this bulky substance in the egg possessed a similar property—possibly by virtue of the possession of some antitoxin, or of some antecedent of an antitoxin; and this might readily explain why the immunity soon passed away from the growing offspring. At any rate the evidence for the idioplasm having become itself affected seems extremely precarious and of doubtful value.

This case has been discussed rather fully as it is just one of those instances in which the meaning of "inheritance of acquired characters" may be rendered obscure or ambiguous through not clearly emphasising the difference between an influence affecting the idioplasm and one merely restricted to the non-idioplasmic but still living protoplasm.

We could wish, indeed, that the theory of Biogenesis itself had been set forth somewhat less vaguely; it is difficult even to state definitely the main points of the theses embodied in it, but its key-note lies in the idea that the idioplasm is capable of receiving and becoming modified by impressions from without, and that, once such an impress has become one of the characters of the idioplasm of a species, a bias will be manifested which will tend to direct further development along certain definite lines, and thus the course of the future evolution of any given species is profoundly influenced by the steps which, in its ancestral line, it has already traversed.

There is much in Dr. Hertwig's theory which reminds the reader of Nägeli and Lamarck, and, indeed, the author expressly mentions his obligations to these, as well as to many other predecessors, but the original method of treatment, and the many luminous passages with which it is adorned, will ensure a welcome for the book even at the hands of those who are unable to accept the views which it is its chief purpose to express.

J. B. F.

Fossil Plants; for Students of Botany and Geology. Vol. i. By A. C. Seward, M.A., F.G.S., Lecturer in Botany in the University of Cambridge. Pp. 452; with 112 Illustrations. "Cambridge Natural Science Manuals." University Press. 1898.

The need of a trustworthy and readable manual of Fossil Botany has been urgently felt for some time. Within the last few years

botanists generally have begun to wake up to the importance of the subject, but there has been no suitable book to put into the hands of students, and even the teachers have scarcely known what to teach. It is probable that the same want has also been experienced on the geological side.

By far the best general hand-book has hitherto been Count Solms-Laubach's *Fossil Botany*, translated into English for the Clarendon Press, a work which remains indispensable for the advanced student, but which is scarcely suited to rouse the interest of a beginner, and now much needs bringing up to date.

Mr. Seward's book—judging from the first volume—will fill up this gap in scientific literature in a most satisfactory way. He has had a good opportunity and has known how to make use of it. The manual is interesting, accurate and critical; the last quality, above all, is essential to any useful treatment of Fossil Botany. It is safe to say that a large part of the contents of this volume will be absolutely new to all except the few who have kept up with the special literature of Fossil Plants. Apart from the particular subject, the appearance of a thoroughly good and original English text-book on an important branch of botanical science is in itself a matter for congratulation.

The present volume includes a general introduction, occupying six chapters, and the first instalment of the special systematic work, embracing the Thallophyta, Bryophyta and two divisions of Pteridophyta.

The first chapter of the general portion is devoted to a short history of Fossil Botany, interesting enough to make one wish it longer. The author is sympathetic and appreciative in his treatment of the older writers, but shrewd as their judgment often was we cannot help feeling that scientific Fossil Botany really sprang into existence with the advent of the great Brongniart.

A useful chapter follows on the relation of Palæobotany to Botany and Geology. It is to be wished that the caution conveyed in the following words were more generally observed: "In working out any collection of fossil plants, it would be well, therefore, to bear in mind that our aim should be rather to reproduce an accurate fragment of botanical history than to perform feats of determination with hopelessly inadequate specimens. Had this principle been generally followed the number of fossil plant species would be enormously reduced, but the value of the records would be considerably raised" (p. 16).

The third chapter is on geological history. A manual of fossil plants cannot be expected to teach Geology; but the summary given here, with its useful tables of strata, will be of much service to the botanical student. The account of the divisions of the all-important Carboniferous Formation, and of their distribution, strikes us as particularly good.

The general chapters are provided with mottoes—apt and sometimes amusing, especially the quotation from Pope which precedes chapter iv., on the preservation of plants as fossils:—

"The things, we know, are neither rich nor rare,
But wonder how the devil they got there."

This chapter contains, among other things, some interesting details of the processes of silicification and calcification on which the preservation of vegetable remains with structure depends. The author justly lays stress on the extraordinary perfection with which histological structure is often preserved, a point never realised except by those who have themselves examined good specimens. Mr. Seward is convinced that in certain favourable cases even the nuclei of the cells are to be recognised.

Chapter v., on difficulties and sources of error, is very salutary, though "the description of a fragment of the handle of a wedgewood teapot as a curious form of Calamite" (p. 94) was no doubt an extreme case! The author justly insists on the uncertainty of characters drawn from the form and venation of leaves. In fact, external characters generally, when unsupported by evidence from structure, are only to be used with the greatest caution.

Chapter vi., on nomenclature, is commendably short, and free from pedantry.

This brings us to the main part of the book, the systematic exposition of the families of fossil plants. This is very fully done, and gives proof of much research, and of sound criticism, based on personal examination of the actual specimens.

Mr. Seward's remarks on fossil Bacteriology, a subject of which a good deal has been heard lately, are much to the point. We quote one sentence: "Specialists tell us that the accurate determination of species of recent Bacteria is practically hopeless; may we not reasonably conclude that the attempt to specifically characterise fossil forms is absolutely hopeless?" (p. 138).

Among the Algæ the author calls attention to the valuable evidence for the geological history of the Calcareous Siphoneæ, which present a marked contrast to other so-called fossil Algæ, most of which are not Algæ at all.

As regards the Bryophyta the fossil evidence is still almost entirely negative.

It is when we reach the Pteridophyta that the serious interest of fossil remains for the botanist begins. Among the Vascular Cryptogams and Gymnosperms it is not too much to say that the value of the fossil evidence to the comparative morphologist equals that from the recent plants themselves.

The botanical student will at once be struck by the presence of *four* instead of three main divisions of Pteridophyta. The fourth group—Sphenophyllales—is entirely fossil, and in fact only known at present from the Palæozoic rocks.

Among the Equisetales the structure of the recent genus is first described (no doubt for the benefit of geological students), and then the fossil forms are taken in order, beginning with those nearest the living

representatives. The author points out that many of the Calamites had a leaf-sheath, so that this supposed distinction from *Equisetites* falls to the ground.

A thoroughly trustworthy account of Calamarian anatomy is given, in which the common English type *Arthropitys* is treated in the fullest detail. A good new figure is given here, showing the connection between the roots—formerly named *Astromyelon*—and the stem.

The cones are fully described; those with structure preserved, both homosporous and heterosporous are first dealt with, and then, in the light of these, the more doubtful specimens showing external characters only are discussed.

In the treatment of the macroscopic characters of the stem, the provisional genera of Weiss are adopted.

The chapter finishes with an account of the interesting genus *Archæocalamites*, the most ancient member of the family known to us.

The last chapter in the volume, that on the Sphenophyllales, is perhaps the most valuable in the book, for it gives for the first time a coherent and correct account of the whole organisation of these remarkable plants. Previous descriptions, even in the best hand-books, are all either untrustworthy or defective, and until now it has only been by the careful study of original papers that a true idea of the family could be built up. The author's suggestion that these graceful plants may have had a climbing habit is original and worthy of consideration. He adopts the view that this extinct phylum combines Equisetaceous with Lycopodiaceous affinities.

The book, excellent as it is, is not of course free from errors; the most startling perhaps, though an obvious slip, is the inclusion of *Chondrus crispus* among *Phæophyceæ!* The manual was so urgently needed, and fulfils its purpose so well, that we hope there may soon be an opportunity of correcting such slight defects in a second edition.

The illustrations are thoroughly good and business-like. The greater number we owe to the skilled pencil of Mrs. Seward. The second volume will be awaited with considerable interest.

D. H. S.

Lectures on the Theory and Practice of Vaccination. By Robert Cory, M.A., M.D. Cantab., F.R.C.P. Lond. London: Baillière, Tindall & Cox. 1898.

Dr. Cory has for twenty-two years been engaged in the practice and teaching of vaccination, and here in a series of six lectures he has given to the world some account of the results of his unique experience. Lecture I. deals with the reasons which led the legislature of this country to impose the vaccination laws upon the people. It is unfortunately impossible for the opponents of vaccination at the present day to see examples of the horrors which the "hated rite" is calculated to prevent; for as a direct result of the widespread adoption of this most valuable preventive measure small-pox is so much less frequent

than it previously was that the opportunities of studying it in England are now far from numerous and even when they do occur the disease is usually deprived of most of its worst features.

The mere fact that before vaccination was introduced it was an everyday occurrence to meet in the streets numbers of people bearing all the disfigurement of small-pox pitting, whilst now it is quite an exceptional circumstance to see such a case, is sufficient evidence of what vaccination has done. But the very absence of such examples tends to make one forget the horrors of small-pox and to tolerate senseless agitators who attempt to convert others to their own absurd theories.

To form a due estimate of the matter one must be in a position to judge on the one hand of the evils of the disease to be exterminated and, on the other, of the advantages claimed for the means proposed for the purpose. In the present instance we are mercifully deprived of the former and it is perhaps, therefore, better to take the opinion of one who lived at a time shortly after the discovery of vaccination and who was therefore in a position to estimate the evils of small-pox and the advantages of vaccination.

Mr. Cross, writing in 1820 (twenty-two years after the discovery of vaccination) of the epidemic of small-pox which visited Norwich in 1819, says in conclusion: "I advocate vaccination because I believe it to be the most powerful means of preventing the misery attendant on disease and of saving human life which Providence has vouchsafed to put into the hands of man; my time has been given up to the gratuitous practice of it, because I can thus do more good amongst the poor than by prescribing pills and potions, and I regard every drop of the vaccine ichor as the most active material that can be admitted into the list of our prophylactic remedies. I am therefore grateful to the philosopher who has taught us to wield this weapon of defence in overcoming *the worst of human maladies*."

And this is the unbiassed opinion of a man fully capable of forming a sound judgment and having the knowledge born of experience of small-pox unmodified by vaccinia and of the improvements which followed on the introduction of the inoculation advocated by Jenner.

Dr. Cory has had the good sense to give his information in a tabular form wherever possible. Thus the tables on pp. 12-33 show clearly the influence of vaccination in delaying the average age at which small-pox makes its attacks, and further the additional security conferred by several incisions as compared with one only. For instance, in those cases where the patient was admittedly unvaccinated the average age at which small-pox occurred was 6·58 years. In those stated to have been vaccinated, but having no scars, 9·86 years; in those having one scar, 17·77 years; two scars, 17·82 years, and in those having five or more scars, 19·3 years.

The table opposite page 6 is also very instructive. It shows by means of vertical lines the average yearly deaths from small-pox per 100,000 inhabitants in Prussia, with compulsory vaccination and

compulsory revaccination at the age of twelve years; Holland, with compulsory vaccination of children before entering a school, and of Austria, without compulsory vaccination. In the first case, that of Prussia with compulsory vaccination and compulsory revaccination at the age of twelve years, the vertical line representing the number of cases of small-pox is nearly $3\frac{1}{2}$ inches long and indicates about ninety cases for the years immediately preceding the passing of the vaccination law, whilst the same line subsequently to the passing of the law in no year projects more than about one-eighth of an inch above the base line.

In the case of Holland, as might be expected from the absence of compulsory revaccination, things are rather less satisfactory. Before the passing of the law the vertical line is again about $3\frac{1}{2}$ inches long and represents about ninety cases per 100,000 of the inhabitants, whilst after the law was passed for several years the line remained very short; but in 1883 it was rather over $\frac{1}{2}$ inch and represented about fifteen cases. In Austria, where there is no compulsory vaccination the average yearly deaths from small-pox per 100,000 of the inhabitants in 1868-1874 were represented by a line $4\frac{3}{4}$ inches long (about 120 cases) and since that time the line has never been less than $1\frac{1}{2}$ inches, it has in one year been $3\frac{1}{4}$ inches and in another $3\frac{3}{4}$, representing about eighty-two and ninety-seven cases respectively.

It is difficult to give by means of mere figures any idea of the effect produced on the mind by a table of this kind which bring forcibly before one the actual facts of the case. The extraordinary diminution in the number of deaths from small-pox in those countries adopting vaccination, contrasted with the continued high mortality in countries where such precautions are neglected, shows very vividly the immense advantages to be obtained from a proper use of the means ready to our hands and no one with an unprejudiced mind who cares to read this chapter can fail to appreciate the value of vaccination as a preventive of small-pox.

In the second Lecture Dr. Cory gives an account of the histology of the vaccine and small-pox vesicles. The account is illustrated by drawings and photographs, and Dr. Cory incidentally shows how different is the structure of the syphilitic Chancre, such demonstration seeming desirable from the fact of the statement having been made that every vaccination vesicle is a lesion of a syphilitic nature.

The third Lecture is devoted to a consideration of the differences between a primary and a secondary vaccination. By a series of tables and figures Dr. Cory has been able to place the matter in a clear light, and on the interesting subject of how far vaccination can be regarded as of use in cases where patients have already been exposed to infection he shows that vaccination to be of use must be performed at all events within the first four days after such exposure.

The eruptions that occasionally follow vaccination are treated in Lecture IV., and this important section has been illustrated by means

of coloured drawings of the more frequently seen affections. Dr. Cory's reasoning on the vexed question of how far these eruptions are directly due to vaccination is close and accurate. Moreover his observations are marked by sound common-sense and knowledge of his subject, and we cannot do better than recommend all who seek information on this point to refer to his work.

The practical details of vaccination occupy Lecture V. It goes without saying that the experience of a man like the author, who has had such ample opportunities of observation and such wide acquaintance with the practical work of vaccination, who, moreover, is such a past-master in all essential details that his success for the past twenty-two years has averaged 96·18 per cent. is invaluable, and specially interesting is it to have the results of his experience of the much-discussed question of insusceptibility. Among 16,000 first attempts of vaccination with humanised lymph Dr. Cory has had fourteen failures, being at the rate of one failure in 1140 children operated upon.

Amongst 21,781 children vaccinated on the arm with calf lymph he has experienced seventy failures at a first attempt, being at the rate of one failure in 311 children operated on. From the above figures and certain calculations, which it is unnecessary to enter into here, it has been determined that one case of statutory insusceptibility as evidenced by failure to obtain any vaccine vesicle in a given child after three several attempts at vaccination, may be looked for in every 6,684,495 cases when working with calf lymph, whilst with humanised lymph the figures stand at one in 329,232,000, so that there is not any great probability of numerous cases of insusceptibility occurring in the practice of a country vaccination!

The statistics given as to the keeping qualities of calf and human lymph on points and in tubes are of utility, and of especial importance are the author's observations and clever illustrations of the relative effects of vaccinating in few or many places.

We fancy there is a plate missing somewhere, as we have failed to discover the promised figure of the vaccinated calf, method of applying forceps, etc. The chapter concludes with a tabulated statement of the symptoms observed in a case of vaccination from the first to the twenty-first day, and some observations on secondary vaccinations.

The last Lecture is devoted to a discussion of the relations of cow-pox, horse-pox, and camel-pox to small-pox, and Dr. Cory comes to the conclusion that vaccinia is but a modified form of small-pox, and that small-pox is the origin of cow-pox, horse-pox and camel-pox.

Throughout the 122 pages of which the work consists the author's statements and conclusions are characterised by an evidence of wide experience, keen insight and sound common-sense, and our only regret is that with such extensive knowledge and practical experience Dr. Cory has been content to publish so small a volume. We hope that in a second edition he may see fit to enlarge it considerably.

Essays on Museums and other Subjects connected with Natural History. By Sir W. H. Flower, K.C.B., F.R.S. London: Macmillan & Co., Ltd., 1898.

This elegant volume contains a reprint of various addresses, lectures and obituary notices, delivered and written by their author within the past twenty-eight years—the earliest (1870) being his Introductory Lecture as Hunterian Professor of Comparative Anatomy to the Royal College of Surgeons, the latest his article on "Boys' Museums," which appeared in *Chambers' Edinburgh Journal* for April, 1897. The contents of the book are arranged under four sections, *viz.*: one of 96 pp. dealing with "Museums," the next of 138 pp. with "General Biology," a third of 122 pp. devoted to "Anthropology," and a fourth of 34 pp. embracing some "Biographical Sketches," making a total of 390 pp. in all.

The author's real work in science and scientific education, of which so many of these essays are the popular outcome, now stands monumental in our two greatest London Biological Museums, and the views which the essays contain are sufficiently well known and have been already sufficiently adopted and criticised to render it needless here to comment upon them in detail. A few trivial alterations necessary to bring this work up to date, and a preface, alone constitute the novel portions of the book; and of these the latter bears a melancholy strain in the declaration that the decision to publish the work has been the outcome of "an enforced period of restraint from active occupation". By his charming personality and the adoption of ever peaceable and conciliatory methods, the author, friend of Darwin and Huxley, a working naturalist whose "scientific life began before the publication of the 'Origin of Species,'" has won for himself a popularity and a deservedly representative position among English-speaking zoologists, and has been honoured in the awards of the highest continental distinctions. Respect for the work and views of his contemporaries and abhorrence of the aggressive appear to have been the guiding principles in his action, and to those who know him the present volume will remain a lasting token of affection and goodwill. Throughout its pages we meet with due recognition of the help afforded him by others, and we accordingly regret the absence of his Royal Institution Lecture of 1886 on the "Wings of Birds," in which there was first made public the memorable rediscovery of "aquincubity," so lamentably associated with the late Richard Wray, than whom Sir W. Flower has had no more ardent admirer nor loyal lieutenant in the later and crowning labours of his life. We cannot allow the opportunity to pass of congratulating the publishers upon the choice and get up of the cover of this work, so strongly in contrast with the familiar green cover of their scientific text-books.

Practical Plant Physiology. An Introduction to Original Research for Students and Teachers of Natural Science, Medicine, Agriculture and Forestry. By Dr. W. Detmer, Professor of Botany in the University of Jena. Translated from the second German edition by S. A. Moor, M.A., Principal of the Gorasia College, India. London: Swan Sonnenschein & Co. New York: The Macmillan Co., 1898.

Those who have used Prof. Detmer's book will be glad to see an English translation which will render it available for the many students who are unable to read German. It must be confessed that the translation itself is not very attractive, and although this does not perhaps affect seriously the value of the book as a working guide, it greatly detracts from the pleasure of reading it.

It is not without some feeling of melancholy that one reads that the book is intended for those (amongst others) interested in Medicine, Agriculture and Forestry. Most of those who devote themselves to the two last-named pursuits in this country would consider such a course to be a pure waste of time; and with the modern contraction of the liberal scientific education which used to form part of the medical curriculum, it is to be feared that but few students in this profession will have much use for the book. But for those who are really interested in Physiology in the widest sense, Dr. Detmer's book provides a good introduction in so far as its relations to plant life are concerned.

Algemeine Physiologie, Ein Grundriss der Lehre von Leben, von Max Verworn, a. o. Professor an der Med. Facultät der Universität Jena. Zweite neu bearbeitete Auflage, mit 285 Abbildungen. Jena: Gustav Fischer, 1897.

To many people the appearance of a new edition, enlarged and improved, of Verworn's *Algemeine Physiologie* will come as a welcome addition to physiological literature, and even those who do not sympathise with the author's views will admit the interesting nature of the book. Of course in a work embracing so wide a field as the present volume of about 600 pages, the method of treatment is necessarily somewhat sketchy and unequal, but in spite of this the large amount of original work and of suggestive points of view will certainly assure for it a welcome at the hands of those who are interested in the physiological phenomena of living protoplasm.

Organographie der Pflanzen, insbesondere der Archegoniaten und Samenpflanzen. Von Dr. K. Goebel, Professor an der Universität München, Erster Theil. Algemen Organographie, mit 130 Abbildingen im Text. Jena: Gustav Fischer, 1898.

Prof. Goebel's book is one which should appeal to a wide circle of readers, for it provides a clear and connected exposition of the new vegetable morphology, in which the old formal treatment is almost

abandoned, to be replaced by one which seeks to unveil the causes which have operated on the plastic vegetable protoplasm and have resulted in the production of the manifold forms of the plant world around us. The writer is peculiarly well fitted for his task in-as-much as he has been himself one of the foremost investigators in this field. Prof. Goebel holds strongly that metamorphosis of a primitive structure is due to a change of function and hence it is useless to attempt to frame a scientific morphology without paying due regard to physiological circumstances.

The chapter on concrescence and abortion is very interesting as a summary of striking examples illustrating the author's standpoint.

Differentiation of form might however be conceivably due to an initial change taking place in the essential protoplasmic element—idioplasm or whatever else we call it—which results in a *diverse* response to a similar environment, and then selection would operate in eliminating the unfit and the less fit, so that finally only those forms would survive which were capable of suitably responding to the exigencies of their surroundings.

The sections treating of relations of symmetry and of the variations in the development of organs at different periods are for the most part based on the previous writings of the author, but nevertheless they have gained much from the way in which they are handled in their present form.

It is however surprising to find the old hypothesis of "*stoff und form*" revived in its crudest form on page 38. This hypothesis merely restates the problems to be solved in terms of substances as to the nature and even the existence of which we are entirely ignorant, and it only obscures the whole matter instead of clearing it up, to conjure with such figments of the imagination. But apart from this and a few other passages the book is an admirable one, and it would be ungracious to find too much fault on these grounds with a book so full of interesting matter that one does not want to lay it down till the last page is reached.

Outlines of Vertebrate Palæontology, for Students of Zoology. By A. Smith Woodward. Cambridge: University Press, 1898. (Cambridge Natural Science Manuals, Biological Series.)

This volume of 459 pages, with over 200 admirable illustrations, is most welcome, and we congratulate both the author and editors upon it. Palæontology, and that more especially of the vertebrata, has of late years been sorely neglected by a large section of our younger teachers and students. The intensity of comparative embryological research and a far too predominant pursuit of the "Schnitt Serie" method, together with other modes of investigation which favour broad generalisation, have almost blinded them to the more solid and tangible truths which lie buried in the rocks. And this movement has gone so far that there have not been wanting those who would not even admit it a branch

of Morphology, restricting that term solely to the study of the yet living forms. When, however, we turn to the record of progress, and consider the more revolutionary of our classificatory schemes, which after all are but popular expression of the growth of knowledge, it must be admitted that the influence of palæontology is paramount, and would seem likely to continue so. In their direct bearing upon our interest in living organisms, what more luminous than the discoveries of Seeley and Andrews on the Plesiosaurian limb girdles (so intuitively expressed in the generic name *Cryptoclidus*) as helping us towards a better conception of the affinities of the anomalous Chelonia; or the wonderful series of Permian fossils forming the "Eotetrapoda" of Credner, as showing that after all Hatteria, as affecting our conceptions of the inter-relationships of the lower terrestrial vertebrata, is perhaps the most wonderful and structurally central of those extant; or again, the unearthing in the United States of better and more complete remains of the Ancylopoda, as affecting our time-honoured and most cherished conceptions of correlation in tooth and limb structure among mammals? Palæontological discoveries such as these, like those of camels having a full series of incisors, of annectant giraffine forms, and the like, have not been lost sight of by those who take a broad survey of progress; and, considered alone, they serve as examples of palæontological study, having a far-reaching influence on our ideas of inter-relationship and structural affinity which transcends those of most purely embryological investigations, and justify the assertion that palæontology is not only a branch of morphology, but a foremost one, perhaps more forcible than the rest, and that the promise given in the earlier discovery of Archæopteryx and the Odontornithes has been amply fulfilled. And as concerning the palæontology of the vertebrata it may be remarked that since Huxley's memorable *Anatomy of Vertebrated Animals*, no vertebrate text-book has accorded the subject fitting recognition. In the work before us, the aforenamed important topics receive due treatment, and ample allusion is to be found to the splendid series of mammalian remains described from the United States deposits by Cope, Marsh, Osborn, Scott and Wortmann, and their associates, as to the work of Marsh, Dollo and Hulke on the Dinosauria; of Seeley and Newton on the Anomodontia; of Moreno and Lydekker on the fossil vertebrata of the Argentines; of Ameghino, Forsyth Major and others, which with them rank foremost in interest among morphological discoveries of recent years having tangible and far-reaching results. Nor has the author of the present volume been behind his fellow-workers in contributing to this end. His investigations on and classification of the fishes are now universally recognised and adopted, and it is in no sense derogatory to the text-books of Palæontology by Nicholson and Lydekker and Zittel, which since the memorable treatise by Owen have been foremost in the field, to say that the present one for the first time places the student in possession of a work in which the subject is laid before them in a concise and readable form, not over-

weighted with stratigraphical considerations. The author's name is itself a guarantee of thoroughness and scholarly research. His Museum catalogue, and the miscellaneous articles which in the intervals of more serious work have fallen from his pen, led us to expect a really good book, and in this we have not been disappointed.

Four hundred and ten pages of the work are devoted to a systematic treatment of the vertebrata taken in ascending order of classification; and of the thirty pages which remain, eight are given over to an "Introduction" dealing in a comprehensive manner with certain broad principles, and the concluding twenty-one to a consideration of "the succession of the vertebrate faunas," the whole closing with a most admirable bibliography arranged on a novel scheme which facilitates reference. In the concluding section of the book the author deals with questions of geographical distribution as bearing on the isolation of continental areas, and upon this, especially as concerning the American continent and supposed isolation since cretaceous times, we cannot altogether follow him, since his theory is in part irreconcilable with facts of distribution of living mammals.

Among the classificatory systems adopted by the author, we hail with satisfaction those of Cope, and that of the Rhychocephalia by Boulenger; and it was to have been expected that the fishes would be arranged in accordance with his own recent scheme, fully developed in his British Museum catalogues. We cannot allow to pass unnoticed, however, his bold persistence in the association of the pteraspid, cephalaspid and pterychthyid forms (with a caution it is true) with the cyclostomi, rendered the more dangerous as it is by the unwarrantable statement, in defining the class, that "it is generally admitted that the existing cyclostomes or marsipobranches are . . . degenerate". Nor can we see sufficient justification for the continued association of the Coccosteids (Arthrodira) with the Dipnoi. As concerning the author's diagnosis of the latter, it is a remarkable fact that neither he nor any other distinguished palæontologist who has thus far written upon them appear to us to have sufficiently emphasised the really distinctive character of the group, *viz.*, that the fact that "the dentition has always been confined to the inner bones of the mouth" is the expression of preponderating development of the palatopterygoid over the premaxillo-maxillary arcade, the precise converse of that occurring in all other gnathostomata. And, concerning this, we would point out that from a knowledge of the Stegocephalia our living Urodela would appear to have undergone an essentially similar change (*Tylototriton* alone excepted), and to be therefore in respect to their jaw apparatus as to their digital skeleton one and all degenerate (a conclusion based on the facts of palæontology which the study of the living alone would not suggest), and that consequently we may reasonably suspect the existence of premaxillo-maxillary bones in a vestigial condition among the earlier Dipnoi, especially if the arguments of Dollo in defence of a belief in their crossopterygian origin be, as we consider them, sound.

Since the author gives prominence to morphological considerations, we the more regret his too ready adoption of Hasse's classification by vertebral characters, which has always appeared to us somewhat premature and overdone, and also of the full details of Bashford Dean's description of the Cladoselache fins, which we consider insufficiently established; while, in connection with the question of median fin supports, we could have desired reference to the important observations of Bridge on those of the recent Teleostomi. Mention might also have been made of the temporal fossæ of *Loxomma*, as an important structural departure among the Stegocephalia, and of the compound nature of the sacrum in the Palæobatrachidæ, as also of the remarkable Italian fossil Anura, described by Portis in 1885. And, again, in diagnosing certain of the Reptilian orders, greater stress might have been laid on the forward extension of the pterygoids to meet the Vomers (as, for example, in the account given of the Plesiosauria on p. 159, as compared with that of the Ichthyosauria on p. 177), which all recent investigation has shown to be a character lying at the root of the Sauropsidan series.

In questions of nomenclature the author is not always consistent, for in the use of synonyms and choice of names he has not adhered to any fixed rule. For example, if "Predentata" being admitted as a synonym for the Dinosauria Ornithopoda, why not Pterosauria for the Ornithosauria and Amphibia for Batrachia (justly revived on grounds of priority) since these have long come into general use? And as regards some of the author's determinations of affinity, we fail to see the reason of his action; as, for example, in the placing of the *Protothylacinus* of the Patagonian Tertiary among the Creodonta. The Tillodontia are retained among the Rodentia, and the remarkable suggestion is implied that the Creodonta may have originated among lowly mammalian forms in the Trias or Jura. These are among the more questionable topics which call for comment and reconsideration, together with an occasional misuse of technical terms, as, for example, the reference to an "abdomen" in a fish (*i.e.*, a distinction between abdominal and caudal regions of the body)—matters all of them which mostly affect the interpretation of parts and mere differences in opinion as to ideas and the limitations of terminology. They do not in the least detract from the value of the work, which must rank foremost among current text-books of vertebrate palæontology. The discovery during the last half decade of *Nesopithecus* by Forsyth Major, of *Pithecanthropus* by Dubois, the description by Traquair of *Palæospondylus*, like the still more recent announcement by him of Silurian shark remains and by Marsh of an apparent amphibian footprint in the Devonian, show that vertebrate palæontology is full of promise for the future, and we rejoice in the present book as one that will do much towards reinstating this most tangible, but none too well-recognised, branch of Morphology.

G. B. E.

The Principles of Biology. By Herbert Spencer. Vol. i. Revised and Enlarged Edition. London: Williams & Norgate, 1898.

It is with great pleasure that we welcome the appearance of the first volume of the revised edition of Mr. Herbert Spencer's *Principles of Biology*. It is hardly possible to overestimate the effect exerted, some thirty-four years ago, by the first edition of this important work, and if it is now less familiar to the younger generation of students, this is chiefly due to the rapid growth of knowledge in all departments of Botany and Zoology which tends to render earlier general works less able to reflect the trend of current thought.

The new edition, however, is greatly enlarged and brought up to date, and will form a delightful and indispensable occupant of the library, not only of the biologist, but also of every one who is interested in the philosophical problems which are inseparably associated with a study of the living organism. The author, as ever, generously acknowledges the aid which he has received from various persons—an aid which the enormous literature renders it imperative for any one to seek who attempts to synthesise a system of Philosophy on so wide a basis as that covered by Mr. Spencer.